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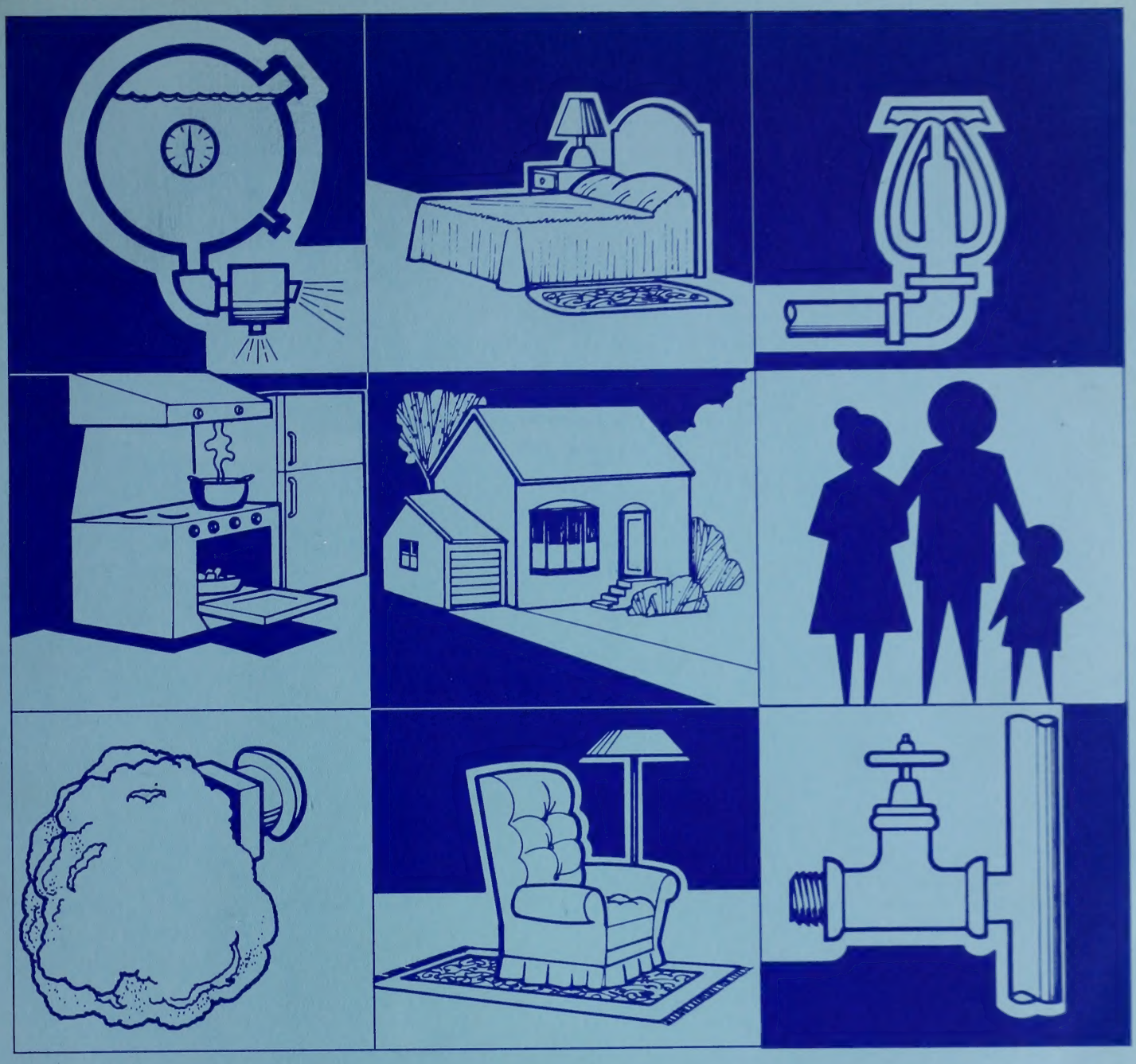

U.S. DEPARTMENT OF COMMERCE

NATIONAL FIRE PREVENTION AND CONTROL ADMINISTRATION

National Fire Safety and Research Office

STUDY TO ESTABLISH THE EXISTING AUTOMATIC FIRE SUPPRESSION TECHNOLOGY FOR USE IN RESIDENTIAL OCCUPANCIES

PENNSYLVANIA STATE UNIVERSITY
DEC 13 1978
COLLECTION

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STUDY TO ESTABLISH THE EXISTING AUTOMATIC FIRE SUPPRESION TECHNOLOGY FOR USE IN RESIDENTIAL OCCUPANCIES

Prepared for:

U.S. DEPARTMENT OF COMMERCE
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1-0 ABSTRACT

1-0 ABSTRACT

1-1 This report describes a study to establish the extent to which currently available automatic suppression systems will be effective in reducing the National Residential Fire Loss. It further identifies areas where systems can be improved to be more acceptable and useful in response to this basic objective.

1-2 The character of residential fire (in single and multi-family dwellings) was established by a review of available fire record and fire research information and candidate systems were selected from available suppression systems. Three specific systems were selected and evaluated to determine the factors that would influence their acceptance by users (occupants or owners of residences) and to determine how their use would be influenced by insurance companies, regulatory agencies, developers, designers, builders, installers and manufacturers.

1-3 The selected systems were evaluated to determine factors which would influence their use and how that use would impact on the National Residential Fire Loss.

1-4 Potential improvements in these systems to make them more acceptable and responsive to the Residential Fire Problem were studied and suggestions made for improvements.

1-5 It was determined that the National Residential Fire Loss can be reduced by greater than 50% if suppression systems can be installed in all residences by 1990. Such a system must be a net zero cost system (initial cost written off over a reasonable period by some type of savings). Public education to improve awareness of the residential fire problem and the ability of a suppression system to cope with that problem is needed. It is unlikely that suppression systems will be installed in existing buildings unless packaged or self-contained systems are developed.

1-6 Recommendations are made with respect to:

- o the development of "package systems",
- o studies to develop more effective and less expensive residential sprinkler systems,
- o the modification of existing national standards,
- o public education,
- o the establishment of a standardized residential fire test procedure.

2-0 DISCUSSION

2.0 DISCUSSION

2-1 INTRODUCTION

2-1.1 Residential fire in the United States results in the annual death of 6,000 to 7,000 people and causes a property loss exceeding one billion dollars. Each year, approximately 4 million families will experience a minor fire in their residence while approximately 800,000 will experience a serious fire. The probability is high that most people in the United States will face an accidental fire in their home. Fire will intimately touch the lives of almost every person in the United States.

2-1.2 Much has been done in an attempt to solve the Residential Fire Problem. During 1965, the National Fire Protection Association (NFPA) created a Home Fire Alarm Standard which encourages installation of residential smoke and fire detectors. Several model building codes and some States and municipalities now require that such detectors be installed in homes and apartments. The fire safety community is presently searching for better test methods and data on which to base fire detector installation and design.

2-1.3 The next logical step in the solution of the Residential Fire Problem is to provide a means for rapid fire control upon detection of fire. The purpose of this study is to determine if automatic fire control systems are or can be made useful in protecting residences and are a viable solution to the Residential Fire Problem.

2-1.4 While there is much information suggesting that automatic residential suppression systems are not feasible, Chandler's (36) remarks, made in 1965, seem appropriate. He stated several reasons why residential fire detection systems would not be widely used, citing such conditions as:

- Lack of an appropriate installation standard
- Lack of equipment designed specifically for residential use
- Lack of a distribution and service network
- Excessive cost
- General apathy on the part of the public,

as being reasons why residential fire detectors would not be used. While residential fire detectors are now being marketed on a nationwide basis, the same arguments can be cited as to why automatic residential fire suppression systems will not be used.

2-2 OBJECTIVE/APPROACH

2-2.1 Objective

The objective of this study was to determine if automatic suppression systems can significantly reduce the National Residential Fire Loss in single and multi-family dwellings. If such systems exist or if they can be developed, a further objective was to characterize those systems and determine what was needed to develop them so that they can be made available to the public.

2-2.2 Approach

2-2.2.1 Study Organization

The study was organized into three interrelated steps.

2-2.2.2 Step 1

Step 1 consisted of characterizing automatic suppression systems which would be acceptable to the public and to the various groups associated with the design, manufacture, sale and approval of automatic residential fire suppression systems. This was done through a series of personal interviews with persons potentially interested in automatic residential fire suppression systems and by reviewing the literature on fire research and on fire loss experience to determine the necessary performance characteristics of such systems.

2-2.2.3 Step 2

2-2.2.3.1 Step 2 consisted of evaluating the loss prevention ability of the candidate system identified during Step 1. This evaluation was done through the use of a logic tree approach to the residential fire problem.

2-2.2.3.2 The logic tree approach permits a quantitative evaluation of the effect of an automatic residential suppression system on the National Residential Fire Loss. It is recognized that the accuracy of this approach is limited by the accuracy of the available input data. However, the approach does provide a reasonable approximation of:

- o The relative ability of each type of automatic suppression system to prevent residential fire-related losses. Systems can be ordered as to loss prevention effectiveness.

- o The reduction in the National Residential Fire Loss caused by automatic residential suppression systems (or any other fire control or prevention system).

2-2.2.3.3 The sprinkler system which was deemed most feasible by Step 1 and effective in reducing the National Residential Fire Loss by the logic tree analysis of Step 2, was characterized using the format of an NFPA installation standard.

2-2.2.4 Step 3

Step 3 consisted of determining how an Automatic Residential Sprinkler System could be improved to make it more effective in reducing the National Residential Fire Loss. Improvements in system performance, ability and cost were recommended along with suggestions as to how those improvements might be made so that the public could be provided with a reasonably priced, effective automatic residential sprinkler system.

2-3 CONCLUSIONS AND FINDINGS

2-3.1 General

2-3.1.1 Automatic residential sprinkler systems, which are available today, can significantly reduce the National Residential Fire Loss. If all residences are equipped with such systems, it is estimated that the reduction can be more than 50% (4-6*).

2-3.1.2 Sprinkler systems, as currently marketed, will not achieve this goal unless they can be installed at a significantly lower cost, and installed in existing residences without entering the walls, floors, or ceiling (3-4.2, 3-6).

2-3.1.3 At their present installation cost, automatic residential sprinkler systems are not cost-effective in existing construction. Sprinkler systems will not be used widely in existing construction until a system is developed which is self-contained; one that can be installed as easily as a picture can be hung on a wall. Until such a system is available, the nation's existing residential units will not be provided with automatic fire suppression systems, except by legislative action.

2-3.1.4 Sprinkler systems are not economically feasible in new single family residences because the cost/benefit relationship between sprinklers and reduced construction costs or reduced fire losses (reduced insurance costs) do not justify the cost of sprinklers as we know them today.

2-3.1.5 Currently available automatic sprinkler systems installed in multiple family residences and new single residential developments (i.e., large project) may be cost-effective where building code alternatives or land use alternatives permit construction cost savings comparable to the cost of the sprinkler system (3-6.3)

2-3.1.6 The major factors which may improve system acceptance are, in order of priority:

- o Development of a "Package System" for retrofit which can be installed without opening the finished walls.
- o Development of installation incentives to reduce net cost, such as tax or insurance savings.
- o Development of less expensive systems by reducing both labor and hardware costs.
- o Showing the public that there is a residential fire problem and that a suppression system will control residential fire without excessive water damage.

* Parenthetical notations are used throughout this report to identify important cross-referenced paragraphs.

- o Removal of restrictions to installations - such as requirements for metering, backflow prevention and excessive permit fees.

- o Development of more efficient (less water - better extinguishment) and responsive (faster operating) sprinklers.

- o Improving the appearance of sprinklers.

2-3.1.7 This study did not evaluate the effects of:

- o Fire prevention activities

- o Fire resistant construction methods or materials.

- o Varying the combustibility of the fuel array within a residence

- o Improved manual fire fighting response and/or improved fire detection

- o Varying the susceptibility of people to fire injury,

on the residential fire problem, any of which may modify the value of an installed suppression system.

2-3.2 Selected Suppression System

2-3.2.1 Sprinkler System

A suppression system using water as the agent and similar to available automatic sprinkler systems (NFPA 13 or 13-D) is the most likely candidate suppression system for use in residences. The basic character of this system is unaffected by ownership of the living unit; slightly affected by the character of the housing (single vs multiple family) and strongly affected by the need to retrofit the system into existing buildings.

2-3.2.2 Other Candidate Systems

2-3.2.2.1 Agent/systems other than water were excluded from practical use by a combination of factors including:

- o Cost
- o Agent toxicity
- o Agent-induced damage
- o Practicality/Agent leakage
- o Aesthetics
- o Maintenance
- o False activation

2-3.2.2.2 For example:

- o Halon, carbon dioxide, high expansion foam and dry chemical systems are all too expensive.
- o Carbon dioxide systems produce a lethal atmosphere at an effective extinguishing concentration.
- o Dry chemical and high expansion foam systems cause considerable damage and reduced visibility when they operate.
- o Total flooding halon and carbon dioxide systems require a reasonably tight enclosure to be effective. Leakage from open windows, doors or attic vents could be excessive.
- o The other candidate systems all require special efforts to make them aesthetically acceptable to the homeowner.
- o All the other candidate systems are too susceptible to false actuation.
- o The other candidate systems all require excessive maintenance.

2-3.3 User Acceptance

2-3.3.1 Interviews of potential suppression system users, including homeowners and apartment dwellers in urban, suburban and rural areas showed a general lack of awareness or concern for the residential fire problem. Thirty percent said they did not have a real concern for fire as a threat (3-4.2).

2-3.3.2 Approximately 50% indicated that they would accept a residential suppression system. Fifty percent would not accept a system; 10% rejecting systems because of appearance, 10% because of fear of accidental discharge, and 30% because of the lack of a perceived fire threat (3-4.2, 3-4.3).

2-3.3.3 Cost was a major factor in systems acceptance. When the people who would accept a system were asked about cost, 40% said they would pay if the cost was $.20/sq. ft. or less; 60% would not pay for a system but would accept it at no cost (3-4.2).

2-3.3.4 70% of those interviewed would favor a requirement for systems in new residences if their property taxes would decrease (3-4.8).

2-3.3.5 Routine maintenance of an automatic suppression system will be acceptable to 85% of those who accept a system (3-4.4).

2-3.3.6 The false system actuation tolerance expressed by those interviewed was approximately 90% (3-4.6).

2-3.3.7 It is felt that had these interviews been conducted two years earlier, very few people would have been willing to accept a system, and a greater number would have considered their risk of fire to be minimal. It is probable that the recent saturation advertising campaign of the fire detector industry has made the public more aware of fire.

2-3.3.8 It is likely that an educational/marketing program to explain what a system is and what it does will increase the acceptability of a residential suppression system.

2-3.4 Influences On Use

2-3.4.1 In order to achieve the installation of residential suppression systems, factors which influence the cost (benefits) or practicality of installation need to be recognized.

2-3.4.2 System installation cost can be reduced by:

- Developing flexible piping to reduce the labor needed to install a system.
- Developing system components designed for use in residential occupancies.
- Increasing the system effectiveness, thereby decreasing required system water supply.

2-3.4.3 Benefits for system installation may occur from:

- Lower land, frontage and municipal service costs
- Insurance savings
- Building code trade-offs (multi-family)
- Increased value of home
- Easier access to mortgages - lower interest rates
- Tax incentives - real estate or Federal Income Tax

2-3.4.4 The probability of residential sprinkler system use is increased in:

- Newly developed residential areas, provided local zoning ordinances permit increased density of land use and reduced lot line separations when residences are sprinklered. This can reduce the per-unit cost for land, common services (streets, sewers, sidewalks, police, fire, schools) and utilities which may more than offset the cost of the sprinkler system.
- Multiple family residences if building code alternatives and/or zoning ordinance alternatives are available which permit the builder cost savings in other areas great enough to offset the cost of the sprinkler system.

2-3.4.5 Local regulatory agencies, including health, water, fire and building departments will:

- o Require backflow preventors and meters (3-5.6.1, 3-5.6.2).
- o Require plans/permit by contractor or engineer (3-5.6.1, 3-5.6.4).
- o Discourage do-it-yourself systems (3-5.6.4).
- o Prefer not to have alarm signals transmitted directly to the fire department from the residential suppression systems (3-5.6.3).
- o Consider density of land use increases/side yard reductions when systems are used (3-5.6.4).
- o Permit alternative building code requirements for multiple family residences which are equipped with automatic suppression systems. Those alternative methods may result in cost savings great enough to offset the cost of the suppression system (3-5.6.4, 3-6.3).
- o Not permit building code alternatives for 1 and 2 family residences when automatic suppression systems are used (3-5.6.4).
- o Not require routine system inspection (3-5.6.3, 3-5.6.4).

2-3.4.6 The current requirements for metering or backflow prevention place a major cost burden on suppression systems. The direct cost of the device and the indirect cost of a pump when city pressure is too low to overcome the friction loss of these devices are both significant. Backflow prevention is required because of the purported health hazard of the trapped sprinkler system water (3-5.6.1, 3-5.6.2).

2-3.4.7 Automatic residential suppression systems can produce a nominal home owners insurance premium credit of 5 to 10% and could possibly be as high as 25% if favorable loss experience occurs with system use (3-5.2.1).

2-3.4.8 A new residential suppression system manufacturing, distribution and installation industry will develop to meet the demands for residential systems (3-5.5.2).

2-3.4.9 The manufacturers interviewed indicated concern for product liability associated with widespread use of their products in residential occupancies (3-5.5.2).

2-3.4.10 System installation may present some union juris-

dictional problems; however because the unions involved are associated on the national level, those problems will probably be resolved (3-5.4.2).

2-3.4.11 Residential builders and developers would offer systems as options in new homes, particularly if their competition offers systems (3-5.3.2).

2-3.4.12 There is a potential market for owner installed systems (3-4.5).

2-3.5 National Residential Fire Loss Reduction

The reduction in the National Residential Fire Loss resulting from use of the selected automatic suppression system will be dependent on the number of residences protected. If all residences are so equipped, it is estimated that the reduction will exceed 50%. If systems are required in all new residential construction between now and 1990, it is estimated that the National Residential Fire Loss in 1990 can be reduced 20 to 35% depending upon the cost of the system installed. With voluntary installation of systems (available at an installation cost of $.20 sq. ft.) it is estimated that the 1990 National Residential Fire Loss can be reduced by approximately 10% (4-6).

2-3.6 System Ability to Prevent Injury

2-3.6.1 An automatic sprinkler system using the available thermal detection actuation mechanism can respond in sufficient time to protect people who are outside the room of fire origin. Such a system may also protect people within the room of fire origin, but will probably not do so consistently.

2-3.6.2 Many of those who become victims of residential fire are not responsive to the fire emergency. Age, physical condition, and the use of drugs or intoxicants impede the ability of many fire victims to escape.

2-3.6.3 A sprinkler system using an improved/detection actuation mechanism which can respond consistently to both a flaming and a smoldering fire may be able to consistently protect the people within the room of fire origin when not in direct contact with the fire.

2-3.6.4 Automatic sprinkler systems cannot be relied upon to protect the individual who is in direct contact with the fire. The system may reduce the severity of his injuries depending upon the circumstances of the fire and the speed with which the system operates.

2-4 RECOMMENDATIONS

2-4.1 General

These recommendations are arranged in priority order. They represent opinions of the contractor regarding areas in which specific programs could be established to improve the acceptance and lower the cost of automatic residential sprinkler systems.

2-4.2 Package System

Support a research program to develop a cost-effective packaged or self-contained system that can be installed in an existing building without the necessity of breaking into walls, floors or partitions (retrofit use).

2-4.3 System Effectiveness

Continue and expand ongoing studies to develop low cost residential sprinkler systems having greater extinguishing effectiveness, faster detection capability, and easier installation characteristics. Include studies to establish minimum application rates, water supply (duration) needs, and efficiency of water distribution under actual fire conditions.

2-4.4 NFPA Standards

Encourage the NFPA to incorporate the proposed revisions to NFPA Standards 13, 13D, and 14 contained in this report so as to facilitate the installation of more effective residential suppression systems.

2-4.5 System Quality Assurance

The sale of systems needs to be regulated to assist the public in determining what constitutes an adequate residential fire suppression system. To assure the purchase of adequate systems, control of system installation is desirable. Should inadequate systems be sold to the public and fail to operate properly, publication of that failure could put the entire residential suppression system program in jeopardy. Control should consist of two parts:

- Third party evaluation is needed of system components critical to the operation of the system
- Total system evaluation is needed to ensure the adequacy of system design.

2-4.6 Public Awareness

An education program should be initiated and funded by NFPCA in order to instill in the public an awareness of the fire problem and confidence in an automatic suppression system as a solution to the problem.

2-4.7 Regulatory Agencies/Builders-Designers

A specific education program should be formulated by NFPCA and persued with code enforcing officials, fire departments, builders, and designers to enhance their understanding of automatic residential suppression systems.

2-4.8 System Incentives

A national policy statement is needed to encourage development of:

- Building code incentives that encourage the installation of automatic suppression systems in multi-family housing
- Land use trade-offs when systems are used
- Tax incentives (on federal, state and local levels) to encourage system use.

2-4.9 Backflow Prevention/Meters

Discussions should be initiated with health authorities and water departments to determine if the current regulations for metering and backflow prevention are needed or if they may be eliminated as an encouragement to the installation of suppression systems. Concurrent research should be devoted to the development of products which accomplish metering or unwanted backflow of water without the disadvantages of severe pressure loss or excessive cost.

2-4.10 Standard Residential Fire Test Procedure

2-4.10.1 A project to develop and promulgate a standardized residential fire test procedure is needed. It is recommended that this be a funded ad hoc committee with the secretariate located at the National Bureau of Standards and that it include interested groups such as users, researchers, appliers, testers, manufacturers, and sellers.

2-4.10.2 A standardized residential fire test procedure should be representative of real residential fire conditions. It should form the basis for evaluating systems and system components, as new suppression and detection systems are developed to respond to the need for low cost residential systems.

2-4.10.3 A procedure is also needed to provide a basis for comparing the residential fire investigation work now in process with that planned for the future and to provide assurance that the systems and components which are offered to the public are indeed adequate to meet the needs of residential fire.

2-4.11 Fire Reporting

Persons working in fire reporting areas (NFPCA/NFPA), should be made aware of the analytical methods (decision trees and curves) utilized in this study as one basis for their consideration of the need to collect additional data.

2-4.12 Research

Encourage the development of research programs to develop improved products and installation methods for residential suppression systems.

3-0 USER REQUIREMENTS

3-0 USER REQUIREMENTS

3-1 OBJECTIVE/APPROACH

3-1.1 "User requirements" for automatic residential fire suppression systems are defined as factors affecting system acceptance and effectiveness. Included are factors dealing with:

- o System ability to limit damage and injury
- o System installation and maintenance costs
- o System acceptability by the general public
- o System acceptability by regulatory agencies

3-1.2 The character of residential fire, as expressed in the fire record and the fire research literature, was reviewed to determine the criteria for successful automatic fire suppression system operation.

3-1.3 A preliminary selection of the most likely candidate system was made from known characteristics of all available systems.

3-1.4 These candidate systems were used as a basis in personal interviews with users and others associated with the design, construction, purchase, acceptance and approval of automatic residential fire suppression systems to determine their particular needs and requirements.

3-1.5 The installation costs of each candidate system and cost factors that will affect long term net cost were determined.

3-2 RESIDENTIAL FIRE RECORD/FIRE RESEARCH

3-2.1 Residential Fire Record

3-2.1.1 Documentation

3-2.1.1.1 The fire record, consisting of:

- o Published works and papers of the National Fire Protection Association
- o Published works and papers of government agencies
- o Published works and papers of others,

was reviewed to determine the nature of residential fire. The list of those documents which were reviewed is appended.

3-2.1.2 Fatalities

3-2.1.2.1 Residential fire results in the death of approximately 6,000 to 7,000 people annually according to the National Safety Council (91).

3-2.1.2.2 The National Safety Council (91) also estimated that nearly half of the people who are killed in residential fires are less than 4 years old or more than 65 years old, people who are normally less than responsive to a fire emergency.

3-2.1.2.3 The NFPA reports (65) that approximately 74% of residential fire fatalities occur during the hours between 10:00 p.m. and 10:00 a.m., that period of time in which people may be expected to be asleep or children left unattended.

3-2.1.2.4 Hollis (46) and Halpin (45) have found measurable amounts of alcohol in a significant number of autopsied fire victims.

3-2.1.2.5 Toxic combustion products/oxygen depletion is the primary cause of death in residential fires. Christian and Dubivsky (37) estimate that approximately 75% of the deaths in residential fires are caused by toxic combustion products or oxygen depletion. Halpin (50) estimates that approximately 50% of the fatalities under study resulted from carbon monoxide poisoning while 30% resulted from the combination of carbon monoxide poisoning, previous heart disease and burns. Halpin (45) also estimates that 70 to 80% of the victims were trying to escape when they were overcome.

3-2.1.2.6 While the results of various studies differ, the record shows that between 60 and 75% of the residential fire fatalities involve people who are not totally responsive to the fire emergency. Those people have had their responsiveness impaired by age, alcohol or other drugs, physical handicaps, mental handicaps, or exposure to toxic combustion products.

3-2.1.3 Injuries

National statistics relating to the number of injuries occurring in residential fires are now being developed. It is estimated that 200,000 injuries occur annually based upon extrapolation of reported California injury experience (97) and upon the assumption suggested by "Highlights of the National Household Fire Survey" (106) that the number of reported fires is approximately 15% of the actual number occurring.

3-2.1.4 Property Loss

3-3.1.4.1 The 1974 Residential Property Loss according to the 1975 edition of the "Statistical Abstract of the United States" (115) and "Fires and Fire Losses Classified 1974" (41) is:

	Number of Fires	Total Dollar Loss	Average Dollar Loss Per Fire
One & Two Family Dwellings	661,400	$808,100,000	$1,125
Multiple Family Dwellings	151,500	$299,100,000	$1,975
Combined	812,900	$1,107,200,000	$1,362

3-3.1.4.2 According to this information, the average reported loss per occupied dwelling unit was approximately $16.00 based upon 70 million occupied dwelling units.

3-3.1.4.3 Unofficial insurance industry statistics on paid claims indicate that the average dollar loss per fire is $1800.00 for 1 and 2 family dwellings and $2800.00 for multiple family dwellings.

3-2.1.4.4 Limited information is available regarding distribution of fire size.

3-2.1.4.5 The National Fire Prevention and Control Administration publication "Highlights of the National Household Fire Survey" (106) estimates that approximately 4-1/2 million fires occur in residences annually. This estimate differs from the previously cited NFPA estimate of 800,000 fires. The NFPCA estimate includes small fires which were not reported. The NFPCA estimates that only 10% of the fires were extinguished by fire departments, the remaining 90% being extinguished by occupants. The NFPCA projection includes a much larger percentage of fires originating in the kitchen than does the NFPA estimate.

3-2.1.5 Fire Origin

3-2.1.5.1 According to the NFPA (48) and the Oregon State Fire Marshal (93, 94, 95), approximately 80 to 90% of the residential fires originate in contents while the remaining fires originate in the building structure. Pingree (52) reports that approximately two-thirds of residential fires involving casualties are Class A fires, one-fourth are Class B fires and the rest are Class C fires. The Los Angeles Fire Department reports (69) that 75% of residential fires start in a slow, smoldering state.

3-2.1.5.2 Arson is reported by the NFPA (66) to be a factor in approximately 10 to 20% of residential fires. It is reported to be much more significant in multiple family residences than in single family residences.

3-2.1.5.3 NFPA records (62) show that over 84% of residential fires originate in the normal-use areas such as the living/dining room, kitchen, bedroom and basement. Approximately 9% of the fires originate in closed storage areas, 3% originate outside the building, 2% originate in the bathroom and 2% in the circulation areas.

3-2.1.5.4 The NFPA (65) reports that the majority of residential fires occur between the hours of 10:00 a.m. and 10:00 p.m., those times in which people are expected to be present and active. During this time, approximately 26% of fatal fires occur.

3-2.1.5.5 The residential fire experience in California (96) suggests that there is an even distribution of residential fires during the week, with no particular day of the week having more fires than any other. However, on weekends, more fires occur between the hours of 1:00 a.m. and 4:00

a.m. than on weekdays. During the week, more fires occur between the hours of 7:00 a.m. and 10:00 a.m. than on weekends. The occurrence of fire at a particular time of day for the remaining hours appears to be independent of the day of week.

3-2.1.5.6 The residential fire experience in Oregon (93, 94, 95) for the years 1972 through 1974 shows that approximately 60% of the fires in single family dwellings were detected within 30 minutes of ignition while 38% were detected within 30 to 60 minutes. 2% burned longer than 60 minutes before detection. In multiple family dwellings, 49% of the fires were detected within 30 minutes of ignition, 49% were detected within 30 to 60 minutes and 2% were detected after 60 minutes from ignition. The weighted average is approximately 58% within 30 minutes, 40% within 30 to 60 minutes and 2% over 60 minutes.

3-2.2 Residential Fire Research

3-2.2.1 Documentation

3-3.2.1.1 There has been considerable research into the nature of residential fire. The results of this work have been reported in several published articles and are included in several NFPA standards. A list of those articles and standards which were reviewed is appended.

3-2.2.2 Fire Growth

3-3.2.2.1 The results of fire test work conducted by many investigating organizations involving both source-type fire tests (single fuel array within a room) and actual furnished room fire tests (multiple fuel arrays) indicate that a fire beginning in a fast, flaming state can develop to fully involve the room of origin within approximately 2 minutes. Dangerous conditions can be created in the room of fire origin and throughout the residence within 2 minutes of fire ignition. Examples of such fires are:

- o A spilled flammable liquid fire
- o A fire in a congested array of combustible materials such as would be found in a basement, an attic or a utility room
- o A fire in a wastebasket placed next to upholstered furniture and/or drapes

3-2.2.2.2 Some fire test work shows that a fire which begins in a slow, smoldering state can create dangerous concentrations of toxic combustion gases in the room of origin and throughout the residence; no definite statement can be made regarding the time at which such dangerous conditions are reached.

3-2.2.3 Burning Rate

The burning rate of a flaming room fire just prior to flashover was investigated by Waterman (9). The reported burning rate was approximately 7 to 12 lbs. of combustibles per minute. Assuming a heat release rate of 8,000 BTU's per lb., the heat release of a flaming room fire just prior to flashover is approximately 56,000 to 96,000 BTU's per minute.

3-2.2.4 Fire Control - Water

3-2.2.4.1 The Factory Mutual work (13) suggests that the method of fire spread within and from the room of origin is by convection. They conclude that one way to control a residential fire is by cooling the room of fire origin and the combustion gases to prevent convected energy transfer. The two other fire control mechanisms, cooling the fuel bed and wetting adjacent available fuel supplies, were not investigated as a means of residential fire control in the work reported.

3-2.2.4.2 In order to test the proposed fire control mechanism, Factory Mutual devised a sprinkler head which produces smaller droplets than a conventional sprinkler head. Smaller droplet size should increase the heat absorption efficiency of the water while decreasing its ability to penetrate through the flame plume to the seat of the fire or to wet adjacent fuel supplies. Factory Mutual has concluded that a density of 0.06 gpm per sq. ft. was sufficient to control a bedroom fire using their new sprinkler head.

3-2.2.4.3 Factory Mutual acknowledged the difficulty in extinguishing a deep-seated fire using this control mechanism and suggested that further investigation be done regarding the other two mechanisms of extinguishment, i.e. cooling the fuel bed and wetting adjacent fuel supplies.

3-2.2.4.4 The mechanism of control suggested by Factory Mutual appears to have been proven effective in other fire test situations. Salzberg et al., (28) reported that they could manually control a post flashover residential fire with as little as 16 to 20 gallons of water per 100 sq. ft. of floor area using a 1-inch booster hose with a spray nozzle. The density of application rate was approximately 0.10 to 0.20 gpm per sq. ft.

3-2.2.4.5 Koplon (110) showed that a density of approximately 0.08 gpm per sq. ft. was adequate to control a bedroom test fire using an ordinary sprinkler head.

3-2.2.4.6 Waterman's explanation of flashover (9) suggests that flashover can be prevented by introducing an energy absorbing medium to cool the room environment. This is consistent with the Factory Mutual observations (13).

3-2.2.4.7 *Waterman's estimation of the rate of burning immediately prior to flashover, Salzberg's ability to control post flashover fires with small amounts of water, Koplon's bedroom fire test results, and the Factory Mutual bedroom fire test results all suggest that a relatively small amount of water applied in the proper form can control a residential fire which has reached the flaming stage.*

3-2.2.5 Fire Control - Other Agents

There has not been sufficient residential fire research conducted using those agents to establish other delivery criteria.

3-3. PRELIMINARY SELECTION OF CANDIDATE SYSTEMS

3-3.1 General

3-3.1.1 Candidate Systems using the following agents were specifically evaluated:

- o Carbon dioxide (CO2)
- o Halon 1301 (H)
- o High expansion foam (HXF)
- o Multipurpose dry chemical (DC)
- o Water (AS)

These systems use extinguishing agents known to be effective in extinguishing Class A fires; the principal hazard of a residential occupancy.

3-3.1.2 Three types of water sprinkler systems were considered. Those systems are identified as:

Level I System - (defined by Section 4-2.15) which provides the lowest level of protection afforded by an NFPA Standard 13-D, 1975 Edition system. This system is available for use today.

Level II System - (defined by Section 4-2.16) provides an improved level of protection when compared to a Level I system. This system is also available for use today.

Level III System - (defined by Section 4-2.17) which provides a level of protection superior to a Level II system through the use of a smoke-sensitive sprinkler and remote supervision of the system. This system is not available for use today but can be made available with improved hardware.

3-3.1.3 Design characteristics for the non-water systems are found in Chapter 4 as follows:

SYSTEM	SYSTEM DEFINED BY
High expansion foam	4-2.20
Halon 1301	4-2.18
Carbon dioxide	4-2.19
Multipurpose dry chemical	4-2.21

3-3.2 System Selection

3-3.2.1 Selection criteria for water systems consisted of available NFPA standards, fire research and fire test data supplemented by the experience and knowledge of the study team.

3-3.2.2 Selection criteria for systems using agents, other than water, were primarily based on NFPA standards, and published literature of manufacturers or approval laboratory listings since there was very little of this type of information in the fire research literature.

3-3.2.3 Carbon dioxide, Halon 1301, high expansion foam and multipurpose dry chemical were all eliminated on the basis of cost and practicality. Carbon dioxide and Halon 1301 systems employ agents which are more expensive than water and which must have a tight enclosure if they are to effectively extinguish a Class A fire. It is impractical to anticipate that doors and windows will always be closed in a residential living unit. Currently available equipment for high expansion foam systems is more costly than that available for water systems and of a size that makes it impractical for most dwelling installations. Multipurpose dry chemical is more expensive than water, and the agent can be expected to spread extensively through a residence causing a significant clean-up problem. Currently, there are no dry chemical systems of a size suitable to protect a complete residential living unit.

3-3.2.4 This subjective basis for the selection of candidate systems was verified by the cost analysis described in Chapter 3 and by the Logic Tree described in Chapter 4. Conditions for which each system were evaluated in the total project are shown on Tables 3-3.2.4 A and B.

CANDIDATE SPRINKLER SYSTEM USE

Table 3-3.2.4 A

SYSTEM	INSTALLATION COST ANALYSIS	NET COST ANALYSIS	SYSTEM IMPACT EVALUATION		
			VOLUNTARY BASIS	REQUIRED IN NEW RESIDENCES	USE IN ALL RESIDENCES
LEVEL I	X	X	X	X	X
LEVEL II	X	X		X	
LEVEL III				X	

SYSTEM REFERENCE

Level I System - (defined by Section 4-2.15) which provides the lowest level of protection afforded by NFPA Standard 13-D, 1975 Edition system. This system is available for use today.

Level II System - (defined by Section 4-2.16) provides an improved level of protection when compared to a Level I system.

Level III System - (defined by Section 4-2.17) which provides a level of protection superior to a Level II system through the use of a smoke-sensitive sprinkler and remote supervision of the system. This system is not available for use today but can be made available with improved hardware.

OTHER AGENT SYSTEMS

Table 3-3.2.4B

SYSTEM	INSTALLATION COST EXAMPLE "C"	IMPACT		
		PROPERTY DAMAGE	INJURY	COST
High Expansion Foam	X	X		
Halon 1301	X	X	X	X
Carbon Dioxide	X	X	X	
Multi-Purpose Dry Chemical	X	X		

3-4 INTERVIEWS - POTENTIAL SYSTEM USERS

3-4.1 Procedure

3-4.1.1 Potential system users were interviewed by telephone in November 1976 to determine their reactions to the candidate automatic residential fire suppression systems. The response to those interviews is informative but not necessarily statistically valid because of the limited number of interviews which were conducted.

3-4.1.2 Even though the reaction to automatic residential fire suppression systems appears to be greatly influenced by the concept of commercial automatic sprinkler systems, the reported acceptability was much higher than expected. This is attributed to the residential fire detector Christmas season advertising campaign which was in progress while the interviews were being conducted.

3-4.1.3 The interviews were conducted by telephone with people in the following areas:

- Chicago
- Atlanta
- Philadelphia
- Dallas/Ft. Worth
- Los Angeles

The interviews were evenly divided between the five geographic regions. Interviews were conducted with the owners of single family residences (400 interviews), tenants in multiple family residences (400 interviews), and either owner or tenants living in rural single family residences (200). While a total of 1,000 interviews were conducted, the questions asked were varied, depending upon the response of the person interviewed. This allowed a certain flexibility to explore different ideas which could not have been done had a formal list of questions been used.

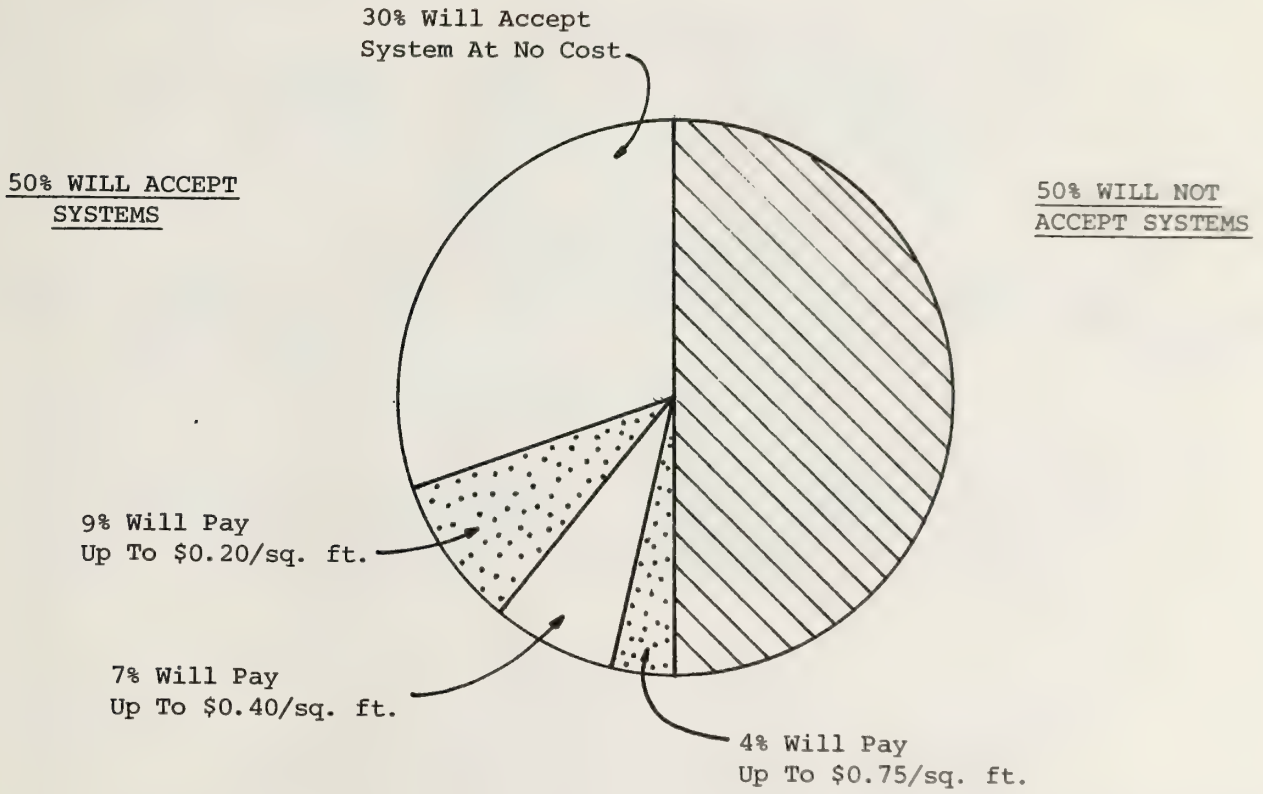
3-4.1.4 The questions asked of the public dealt with:

- Fire awareness
- Acceptability and understanding of suppression systems
- Acceptability of suppression system costs

3-4.2 System Acceptance/Installation Cost

3-4.2.1 Of those people interviewed, 20% would be willing to pay for a system. Nine per cent indicated that they would pay up to the equivalent of $0.20 per sq. ft., 7% would pay up to $0.40 per sq. ft. and 4% would pay up to $0.75 per sq. ft. for a system (9 + 7 + 4 = 20%).

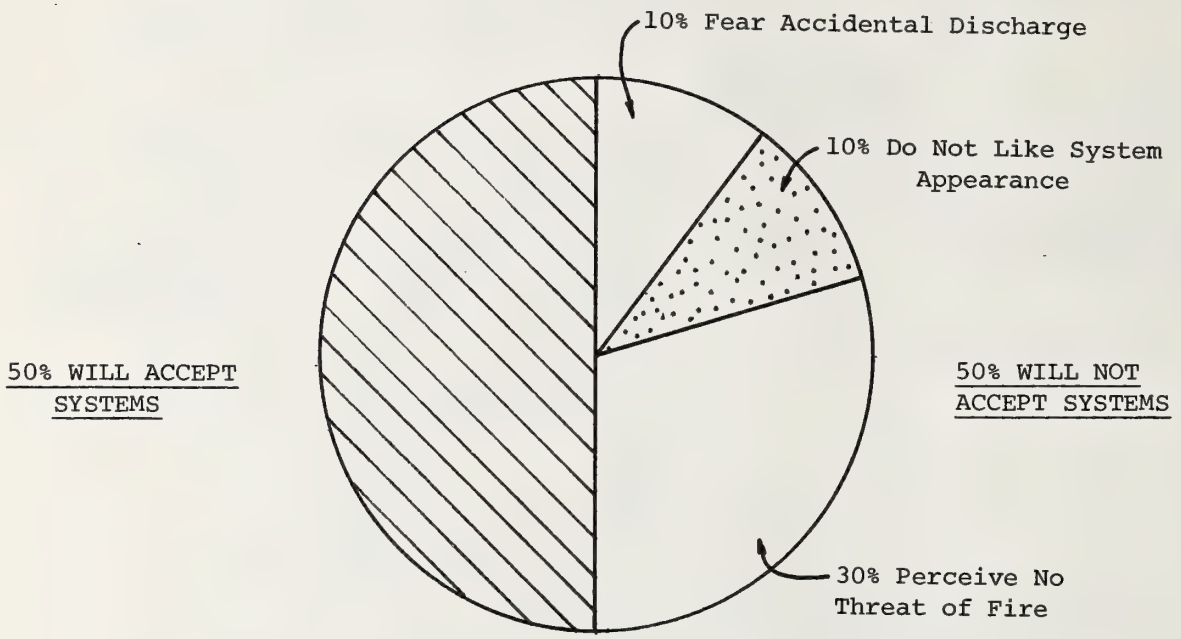
Chart 3-4.2.1



3-4.2.2 Thirty percent would accept a system at no net cost.

3-4.2.3 Half of those interviewed stated that they would not have a system in their residence. Ten percent feared accidental discharge, 10% rejected systems based on appearance and 30% saw no need for a system.

Chart 3-4.2.3


10% Fear Accidental Discharge
10% Do Not Like System Appearance
50% WILL ACCEPT SYSTEMS
50% WILL NOT ACCEPT SYSTEMS
30% Perceive No Threat of Fire

3-4.2.4 An educational/marketing program explaining what an automatic residential suppression system is, how it operates, what it will look like, and what it will do can increase the acceptability of residential systems.

3-4.3 Life Safety/Property Protection

Of the people interviewed who would accept a system in their residence, approximately 10% would not accept a system which protected property only. They wanted a system which would protect both life and property. The remaining 90% would accept a system which would protect property only.

3-4.4 Maintenance

3-4.4.1 Approximately 85% of those people who would accept systems stated that annual maintenance of the system would be acceptable. 15% stated that annual maintenance was unacceptable and would not be conducted.

3-4.4.2 Experience with residential smoke detectors has shown that annual maintenance has not been conducted in 5% of the installations (17).

3-4.5 Installation

3-4.5.1 Approximately 60% of those people who would accept systems stated that they would install it themselves if they could save money over the cost of having a contractor installing the system. 40% stated that they would have a contractor install the system irrespective of the cost savings of installing it themselves.

3-4.5.2 This implies that there is potential for a "do-it-yourself" system. The magnitude of the "do-it-yourself" market will be related to the complexity of system installation.

3-4.6 False Actuation Acceptability

Approximately 90% of the people who would accept systems indicated that they would tolerate a false actuation provided the insurance company paid for subsequent damage. These people would repair the system and return it to service. 10% of the people would not return the system to service.

3-4.7 Fire Insurance Coverage

Approximately 70% of the people who would accept a system stated that they would not reduce the amount of their fire insurance coverage because of the presence of the system. Thirty per cent stated that they would consider reducing their coverage.

3-4.8 Tax Reduction

Approximately 70% of the people who would accept a system stated that they would favor legislation requiring such systems in all new homes in their community provided they received a subsequent reduction in property taxes.

3-4.9 Aesthetics

Approximately 10% of the people interviewed stated that they would not accept a system because it would detract from the appearance of their residence. This is probably a result of the public's concept of a commercial sprinkler system.

3-4.10 False Discharge

Approximately 10% of the people interviewed stated that they feared accidental system discharge and would not have it for that reason. This again emphasizes the need to educate the public as to how a suppression system operates and to maintain low false actuation rates.

3-4.11 Perception of Risk

Approximately 30% of those people interviewed stated that their risk of fire did not warrant installation of a system. This group of people will probably decrease as the public becomes more aware of the residential fire problem, particularly from residential fire detector industry advertising.

3-5 INTERVIEWS - OTHERS INFLUENCING SYSTEM USE

3-5.1 Procedure

3-5.1.1 Personal interviews were conducted with representatives of:

- Fire insurance industry
- Financial institutions
- Real estate concerns
- Residential builders/developers
- System designers and installers
- Trade unions
- Architects/engineers
- Manufacturers of automatic suppression system equipment
- Water utilities
- Health Departments
- Fire Departments
- Building Departments

to determine pertinent reactions to automatic residential fire suppression systems. The response to those interviews is informative, but not necessarily statistically valid because of the limited number of interviews which were conducted.

3-5.2 Fire Insurance/Real Estate/Financial Institutions

3-5.2.1 Fire Insurance Industry

3-5.2.1.1 Personal interviews were conducted with administrative and underwriting personnel from three large insurance companies which operate heavily in the residential fire insurance market, an insurance broker and from the organization which provides technical and rate guidance for most insurance companies. The purpose of those interviews was to determine the effect of a residential sprinkler system as it relates to:

- Fire insurance premium credit
- Extended coverage premium increase
- Administrative procedures to identify, accept and ensure maintenance of an acceptable system.
- Insurability - urban areas
- Insurability - rural areas

3-5.2.1.2 The consensus of those interviewed was that an initial nominal net homeowners insurance premium credit of approximately 5% ($7.50 per year on average premium of $150) would be allowed for a residential type sprinkler system installed in a class rated building (single family residence or small multiple family residence). That premium credit could increase to approximately 25% ($37.50 per year) if a favorable loss ratio develops in protected residences. The credit might vary in large, multiple family residential buildings which are specifically rated (because of their size or unusual construction features) or in buildings which contain both residential and commercial occupancies. This fire insurance premium credit includes an extended coverage premium increase needed to cover the hazard of accidental system discharge or leakage.

3-5.2.1.3 The insurance companies would probably adjust premiums on an experience basis as systems become widely used.

3-5.2.1.4 Because of the nominal amount of premium credit allowed for a system, the insurance companies would not require inspection of the system nor approval of installation plans prior to installation. They would accept the certification of the insurance agent that the system is installed and meets minimum requirements. The insurance policy would not contain a system maintenance clause but would contain a system leakage clause.

3-5.2.1.5 Those interviewed were not receptive to allowing differential credit for various degrees of sprinkler protection. The administrative costs of identifying, evaluating and checking different levels of protection provided by different types of systems would off-set the anticipated premium savings.

3-5.2.1.6 The presence of a system would not materially affect the insurability of an urban residence which is exposed by other structures. The system would not address the exposure fire question unless all structures within a developed area are protected, in which case an increased premium credit might also be available.

3-5.2.1.7 The presence of a system might affect the insurability of a rural residence provided an adequate water supply is maintained. In this case, the major problem is one of protecting against internal fire because of possible delay in fire department response.

3-5.2.2 Real Estate

3-5.2.2.1 Several real estate agents who do business in urban, suburban and rural areas were personally interviewed to determine their views on the cost/benefit impact of an automatic sprinkler system installed in a residence.

3-5.2.2.2 The majority of those interviewed stated that they would promote either an automatic fire detection system or an automatic suppression system as a desirable feature within a residence. Only one person felt that such fire protection features were not promotable items.

3-5.2.2.3 All of those interviewed felt that an automatic fire detection system would not represent a sufficient capital investment on the part of the owner to warrant an increase in appraised value of the residence.

3-5.2.2.4 Half of those interviewed indicated that they thought an automatic suppression system would not increase the appraised value of a residence. The other half thought that a system would increase the appraised value by an amount equivalent to the cost of the system, but not more than 1% of the value of the residence.

3-5.2.2.5 The price which a buyer is willing to pay for a residence is influenced by his perception of the value of the residence compared to his particular wants and needs. If a buyer considers fire safety to be a desirable item, he might pay more for a residence with a suppression system than he would for a residence without one. In order to

improve the resale value of a residence protected by a system, the buying public must perceive the need and value of such a system. This will come about as residential suppression systems become more prevalent. When this occurs, it is estimated that the value of a protected residence may increase by approximately 1%.

3-5.2.3 Financial Institutions

3-5.2.3.1 Personal interviews were conducted with the loan officers of several financial institutions which specialize in home mortgages, operating in urban areas, suburban areas and rural areas. The purpose of the interviews was to determine the effect of an automatic suppression system on loan availability, both to purchase property and to finance a system.

3-5.2.3.2 Those interviewed felt that the presence of a system in a residence would generally make the residence a more worthwhile investment, particularly in a rural area or in the inner-city urban areas.

3-5.2.3.3 The presence of a system in a residence may result in a reduction of the interest rate charged to the home owner on his home mortgage if the systems prove to be effective in reducing the risk of fire. While those interviewed could not comment on the extent of an anticipated mortgage interest rate reduction, a reduction of 0.10% appears to be reasonable.

3-5.2.3.4 All of those interviewed indicated that their institutions would loan money for the purpose of installing a system in a residence. The money would be loaned as a typical home improvement loan.

3-5.2.3.5 All of those interviewed stated that their institutions would not accept a fire insurance policy on a mortgaged property which contained a suppression maintenance clause.

3-5.3 Designers/Builders

3-5.3.1 Architects/Engineers

3-5.3.1.1 Personal interviews were conducted with architects/engineers to determine the practicality of installation of an automatic suppression system in a residence and the aesthetic requirements of a system. The concept of residential suppression systems was new to those individuals interviewed.

3-5.3.1.2 A general negative reaction was obtained because of the concern over the aesthetics of a system. Most of

those interviewed felt that the system would need to be totally concealed in order to be acceptable. A system which uses components compatible with the finish within the room (such as a recessed, chrome-plated pendent sprinkler head used in a living room ceiling) was viewed as being less desirable than a system which uses totally concealed components. A system which uses exposed components which are not compatible with the finish of the space is considered unacceptable. Exposed components are acceptable in spaces which have no finish such as an attic, a crawl space or an unfinished basement.

3-5.3.1.3 Those interviewed indicated that their clients had not expressed a concern regarding fire safety nor had they concerned themselves with the safety of their own residences. They indicated they would not install a system in their individual residences.

3-5.3.1.4 A suppression system can be installed in almost any building. The more novel or innovative architectural approaches will require more expensive camouflaging techniques to provide an aesthetically acceptable system. The cost of camouflaging the system is considered to be in proportion to the cost of a structure using an innovative architectural approach.

3-5.3.2 Residential Builders

3-5.3.2.1 Personal interviews were conducted with several home builders to determine the practicality of installation of automatic suppression systems.

3-5.3.2.2 Those interviewed indicated that their customers have developed an increasing awareness of the residential fire problem as evidenced by the increasing number of requests for smoke detectors in new homes. They felt that they could easily sell systems which could be installed in a typical three or four bedroom single family residence at a cost of $1,000 or less. The systems would be financed as a part of the cost of the residence.

3-5.3.2.3 Those interviewed indicated that they would promote automatic suppression systems, particularly if their competition was not able to offer systems as an option. Conversely, if their competition was able to offer systems, but they were not, they would strive to obtain that capability.

3-5.3.2.4 The building itself would present no problem to installation of a system during construction.

3-5.3.2.5 Those interviewed thought the plumbers union would obtain jurisdiction and install the system along with the rest of the plumbing within the building. This was viewed as the more economical way of having systems installed.

3-5.3.3 Residential Developers

3-5.3.3.1 Personel interviews were conducted with several residential developers to determine the impact of automatic suppression systems on the cost of a residence, the impact of systems on sales and the practicality of system installation.

3-5.3.3.2 The developers interviewed stated that they had been requested to provide additional fire department facilities and/or water supply systems in excess of that needed for domestic use for certain large residential developments. The presence of automatic residential suppression systems could have resulted in cost savings if the need for the additional fire department facilities and water supply capability was eliminated.

3-5.3.3.3 Those interviewed did not foresee the possibility of construction cost savings brought about by the use of automatic suppression systems. They did see the reduction of side yard requirements and increased density of land use as a possible benefit of sprinkler systems. This could reduce the unit cost of land, utilities, roads, etc., and decrease taxes by increasing the tax base.
This is a potential major cost reduction.

3-5.3.3.4 The developers would promote systems in new homes provided the buying public recognized the improved safety and was willing to pay the additional cost of the system. The system would probably be offered as an option rather than as standard equipment. Those interviewed expect that system acceptance will be directly related to the cost of the housing, i.e. greater acceptance in more expensive, luxury type housing.

3-5.3.3.5 Those interviewed foresaw no difficulty in installing a system within a conventional residence.

3-5.3.3.6 Those interviewed did foresee a union jurisdictional problem. The consensus was that the plumbers union would probably obtain jurisdiction and install the systems along with the other plumbing systems. If the plumbers union did not obtain jurisdiction, the cost of the system could

be increased because of the additional administrative problems of having two unions installing piping systems within the residence.

3-5.4 Contractors and Trade Unions

3-5.4.1 Piping System Contractors

3-5.4.1.1 Personal interviews were conducted with several plumbing contractors and automatic sprinkler system contractors. The purpose of those interviews was to determine the practicality and cost of installing and maintaining the proposed systems.

3-5.4.1.2 The plumbing contractors interviewed indicated that they would not actively pursue the market for installing and maintaining systems in residences.

3-5.4.1.3 The plumbing contractors consider a residential sprinkler system to be analogous to a cold water distribution system in terms of installation and maintenance. They indicated that it is conceivable that a sprinkler system can be installed in new construction at a gross cost of $50 per sprinkler.

3-5.4.1.4 The sprinkler system contractors predict a gross price of $100 to $125 per sprinkler as being more realistic than $50 per sprinkler. They do concede that the $50 per sprinkler price is within the realm of possibility on large developments where administrative and engineering costs can be minimized.

3-5.4.2 Trade Unions

3-5.4.2.1 Personal interviews were conducted with pipe fitters, plumbers and sprinkler fitters union personnel to establish the practicality of system installation and to identify possible jurisdiction problems.

3-5.4.2.2 Representatives of all the unions stated that under present agreements, installation of automatic sprinklers is the jurisdiction of the sprinkler fitters union. Sprinkler fitters would be required to install sprinkler systems in residences. Because all of these trades are associated with one national union, any jurisdictional change allowing plumbers or pipe fitters to install sprinkler systems in residences would need to occur on a national level.

3-5.4.2.3 Those interviewed stated that their unions have the manpower capability to handle the increased workload, that their journeymen members are capable of performing the work and that their apprentice programs could include training in the installation of the systems.

3-5.5 Suppression System Component Manufacturers

3-5.5.1 Selected Manufacturers

3-5.5.1.1 Interviews were conducted with manufacturers of sprinkler system components and with a manufacturer of halogenated extinguishing agents.

3-5.5.2 Sprinkler System Component Manufacturers

3-5.5.2.1 The manufacturers interviewed stated that a new residential sprinkler would be developed if the market dictates the need for such a sprinkler.

3-5.5.2.2 The sprinkler manufacturing process will probably become automated and a new residential sprinkler system industry will develop if a large demand is created for residential sprinkler systems. The new industry will probably develop a distribution network which makes system components available through wholesale and retail plumbing supply outlets.

3-5.5.2.3 The manufacturers interviewed indicated concern over potential liability associated with widespread use of their products. They feel that third party approval from a nationally recognized testing laboratory is needed to ensure product quality and protect them from potential product liability. This concern may retard development of residential sprinkler system hardware or may preclude its sale through outlets other than the manufacturers licensees.

3-5.5.3 Halon 1301 Manufacturer

3-5.5.3.1 The manufacturer interviewed indicated that the price of the agent could be reduced to a minimum of approximately $1.25 per lb.

3-5.5.3.2 The manufacturer interviewed indicated that his company would be willing to assist (up to approximately $25,000) in funding a fire investigation program to determine the feasibility of protecting residential occupancies with halon systems.

3-5.6 Local Regulatory Agencies

3-5.6.1 Water Department

3-5.6.1.1 Personal interviews were conducted with water department personnel in several communities to determine requirements for metering, cross-connections between domestic water supplies and sprinkler systems, and administrative procedures.

3-5.6.1.2 Those interviewed indicated that they are strongly opposed to discontinuing the use of meters in lieu of flat rate charges. The domestic water meter is the largest source of friction loss in the supply for a combined domestic/sprinkler system. If the domestic water meter could be eliminated or redesigned to reduce friction loss, the savings could amount to approximately $50 per system in new construction and $150 per system in existing construction.

3-5.6.1.3 Those interviewed indicated that they consider a sprinkler system to be non-potable, requiring a back-flow preventer between the sprinkler system and the domestic water system. The origin of the concept of a sprinkler system as a non-potable water source could not be determined. Technical information or actual case histories of the contamination hazard of a sprinkler system could not be found. The back-flow preventer introduces an approximate 10 psi friction loss in the water supply to the sprinkler system. This friction loss usually requires the use of a booster pump. The cost of the back-flow preventer and booster pump is estimated to be $800, nearly as much as the cost of the system itself.

3-5.6.1.4 Those interviewed indicated that they would require plans for a sprinkler system prepared either by an architect/engineer or by a licensed contractor prior to issuing a permit for installation of the system. A permit would be required at a cost of approximately $5 to $10 per system. They would discourage the owner from installing his own system.

3-5.6.2 Health Department

3-5.6.2.1 Personal interviews were conducted with several health department officials to determine their requirements for cross-connecting domestic water systems and residential sprinkler systems.

3-5.6.2.2 Those interviewed also consider the sprinkler system to be non-potable and require a back-flow preventer between the sprinkler system and the domestic water system.

3-5.6.3 Fire Department

3-5.6.3.1 Personal interviews were conducted with several fire department officials to determine alarm transmission requirements, plan review requirements, inspection requirements and license fees.

3-5.6.3.2 The majority of those interviewed indicated their fire departments would not accept fire alarm signals from residential suppression systems. They do not want the false alarm problem and do not have the equipment necessary to receive signals from a large number of systems. Alarms from residential suppression systems will probably have to be relayed to the fire department through a third party such as a telephone answering service, a "residential central station supervisory alarm company" or a similar entity.

3-5.6.3.3 Approximately half of those interviewed indicated that their departments would routinely inspect automatic suppression systems installed in residences and would require that those systems remain in service even though they may not be required by code. The remaining officials indicated that they would not have the manpower to inspect the systems.

3-5.6.3.4 A fire department permit would not be needed nor would plans be required for installation of a residential sprinkler system.

3-5.6.3.5 Those interviewed indicated that they would not reduce their normal response to an alarm from a protected residence until the value of automatic residential fire suppression systems has been well established. At that time, they would consider a reduction in response.

3-5.6.4 Building Department

3-5.6.4.1 Personal interviews were conducted with several building department officials to determine the administrative requirements of installing a residential suppression system.

3-5.6.4.2 Those interviewed indicated that a permit would be required at an approximate cost of $5 to $10. Plans prepared by an architect/engineer or a licensed contractor would be required prior to issuing a permit.

3-5.6.4.3 Most building department officials interviewed would discourage installation of a system by the owner.

3-5.6.4.4 The building department personnel would inspect the system upon completion of installation as an established requirement for issuing a certificate of occupancy. None of the building department officials interviewed indicated that routine inspections would be made.

3-5.6.4.5 Those interviewed felt that building code trade-offs for residential sprinkler systems in single family residences are not appropriate because so few restrictions are presently placed on single family residential construction. They do feel that code "trade-offs", currently available to multi-family housing, may be extended. They also feel that reduction in zoning ordinance requirements for side yards, lot size and density of land use are appropriate.

3-5.7 Municipal Fire Defense

3-5.7.1 Public Fire Protection Evaluation

Public fire protection was evaluated by use of the "Grading Schedule for Municipal Fire Protection" (74) which local Insurance Services Offices use in evaluating the public fire protection of individual communities within their jurisdiction.

3-5.7.2 Fire Department Requirements

3-5.7.2.1 The "Grading Schedule" fire department requirements for a community are based on the amount of water (fire flow) considered necessary to combat the worst conceivable fire in a building or group of buildings. The number of engine and truck companies needed is directly related to the size of fire flow, the larger the flow the more firemen and fire trucks are needed. Table 3-5.7.2 shows the fire flows recommended for the various structures within a typical city to accomplish the optimum fire insurance rating.

Table 3-5.7.2

REQUIRED FIRE FLOW (GPM)

Use of Buildings	Non-sprinklered	Sprinklered
Shopping Center	5000	3750
Hospital	3750	2750
Central Business District	3500	2750
School	3500	2750
Outlying Commercial	2750	2000
Multiple Family Residential	2500	2000
Single Family Residential	1000	750

3-5.7.2.2 By providing manpower and equipment to protect those parts of a community which have the larger fire flows, the fire department requirements for the residential areas are met. Provision of automatic sprinkler systems in the residential portions of a community will not affect the fire department requirements in existing developed areas.

3-5.7.2.3 It is possible that the provision of automatic residential fire suppression systems may reduce the fire department equipment and manpower requirements in a newly developing community, particularly if the building code requires automatic sprinkler protection in commercial structures. This could result in a reduction in fire department expenses and subsequently,in the community tax structure.

3-5.7.3 Land Use

3-5.7.3.1 Another facet of municipal fire defense is land use restriction. Typically, zoning ordinances set limitations on:

- o Front, rear and side yards
- o Density of land use
- o Lot size

Such limitations are intended,in part, to prevent conflagration type fires by creating "fire breaks" between buildings.

3-5.7.3.2 An automatic residential suppression system can be used as a substitute for space separations (NFPA 80A-1975

indicates that automatic sprinklers are an effective means of controlling exposure fire). The use of systems may permit more efficient land use thereby reducing the land cost for a new residential unit, subsequent property taxes because of smaller lot sizes and development costs.

3-5.8 Building Code Analysis

3-5.8.1 Approach

The 1976 edition of the Uniform Building Code published by the International Conference of Building Officials (79) and the 1975 edition of One and Two Family Dwelling Code published by the nationally recognized Model Code Groups (75) were reviewed to determine if construction cost savings could be realized under those codes by installing an automatic suppression system within a residence. There are 3 basic types of buildings considered in this analysis:

- o One and two family residences
- o Multiple family residences with a maximum height less than 75 feet
- o Multiple family residences with a maximum height over 75 feet

3-5.8.2 Alternative Code Requirements

3-5.8.2.1 Alternative building code requirements recognizing the presence of an automatic suppression system must consider those areas in which the system can be effective such as:

- o The system can function as a fire detection system thereby allowing it to perform as a part of a required fire detection/ alarm system.
- o The system can limit development of fire thereby allowing a longer escape time and reducing the needed emergency exiting facilities.
- o The system can control the spread of fire, thereby decreasing the need for fire walls, space separations between buildings and structural protection.

- The system can extinguish the fire, allowing reduction in the number and/or size of standpipes and hose outlets.

3-5.8.2.2 Because most residential fires originate in the contents, systems are being considered which are effective on a contents fire. Those systems may not consistently control fires originating within the structure, such as in a concealed space below a stairway or in the stud space within a wall. For this reason, alternative code requirements regarding flammability of building and interior finish materials and changes in the requirements for fire stopping within the structure are not considered appropriate. The suppression system will not address the fire problems which those requirements are intended to solve.

3-5.8.2.3 While a detailed analysis of possible alternative building code requirements for use in residences when automatic fire suppression systems are used is beyond the scope of this project, it does appear that significant savings can be developed, particularly in multiple family housing.

3-5.8.3 One and Two Family Residences

3-5.8.3.1 The "One and Two Family Dwelling Code" (75) does not have requirements regarding fire walls, space separations between buildings, structural protection, standpipe and hose systems and emergency egress capacity or travel distance.

3-5.8.3.2 The single requirement in that Code dealing with fire detection/alarm is the requirement of Section R-216 requiring a smoke detector in each dwelling unit.

3-5.8.3.3 Should an automatic suppression system be used which will detect "smoke," the requirement of Section R-216 could be changed to permit the use of the system as a substitute for the "smoke" detector.

3-5.8.4 Multiple Family Residences - 75 Feet or Less in Height

3-5.8.4.1 The Uniform Building Code permits height or area increases when an automatic sprinkler system is provided (Sections 506 and 507) or it permits the substitution of sprinklers for fire resistive construction (Section 508). The Code also permits an increase in the travel distance to an exit (3302(d)), and permits the elimination of the standpipe system (3804 (b)) when sprinklers are provided.

3-5.8.4.2 These types of alternatives could easily make the installation of an automatic suppression system economically feasible in a multiple family residence.

3-5.8.5 Multiple Family Residences Higher Than 75 Feet

3-5.8.5.1 Multiple family residential buildings higher than 75 feet are subject to the special provisions for high rise buildings contained in Section 1807 of the 1976 edition of the Uniform Building Code. These provisions go beyond the fire safety requirements for buildings less than 75 feet high. While that section of the code does contain allowances for the use of automatic sprinkler systems, it is felt that a careful study of that section and of the failure mode of automatic fire suppression systems can identify areas where the provisions of that section of the code may be safely reduced when an automatic residential fire suppression system is used.

3-5.8.5.2 In addition to the foregoing consideration of the high rise provisions, the standpipe requirements of Section 38 should also be considered. It would seem feasible to install a single dry standpipe in a residential building which is completely protected by an automatic residential fire suppression system because the standpipe would be used for manual "mop-up" operations by the fire department. The standpipe should not need a fixed, permanent water supply if the fire department can pump into it through a fire department connection at street level to supply water at all levels.

3-5.8.5.3 Installing a truly effective automatic residential fire suppression system in a multiple family residential building over 75 feet high could result in a considerable cost savings to the owner if building code alternatives are made available which accurately reflect the increased fire safety created by the system.

3-6 DETERMINATION OF SYSTEM COST

3-6.1 Example Systems

3-6.1.1 Single Family Residences - Automatic Residential Sprinkler Systems

3-6.1.1.1 The approximate costs and design/installation problem of automatic residential sprinkler systems using available technology and hardware were determined by designing and cost evaluating example systems for three different single family residences. Level I and II systems were designed for:

- o A one-story, three bedroom, single family residence which has a full basement, but no attic. The protected area in this residence is approximately 2,000 sq. ft. (Example "A" - sketch appended).

- o A two-story, three bedroom, single family residence which has a full basement and an attic. The protected area, excluding the attic, is approximately 2,400 sq. ft.; including the attic, 3,200 sq. ft. (Example "B" - sketch appended).

- o A split-level, three bedroom, single family residence which has a partial basement, a crawl space, but no attic. The protected area in this example is approximately 2,000 sq. ft. (Example "C" - sketch appended).

3-6.1.1.2 The system design considered an available municipal water supply at a static pressure of 50 psi, a 50 ft. water service entrance pipe with a meter (3/4 inch pipe - 5/8 inch meter in existing construction; 1-1/4 inch pipe - 1-1/4 inch meter in new construction), and use of nominal 1/2 inch orifice standard sprinklers discharging at a design density of 0.10 gpm per sq. ft. over a maximum area of 250 sq. ft. Diagrams and hydraulic calculations for these systems are appended.

3-6.1.1.3 A system was also designed for a rural dwelling in which a booster pump would take suction from either the well pump, if it is capable of producing 25 gpm, or from a non-pressurized suction tank. This would require a 25 gpm, 50 psi booster pump, driven by a two horsepower electric motor.

3-6.1.1.4 General observations regarding these example systems are:

- The actual average coverage per sprinkler is approximately 150 sq. ft. when Level I protection is provided or 100 sq. ft. when Level II protection is provided even though the maximum permitted coverage per sprinkler is 256 sq. ft. according to NFPA Standard #13D. The residences are subdivided in such a way that the maximum spacing permitted by NFPA Standard #13D could not be used.

- For existing construction, the municipal water supply was not adequate. By providing a booster pump and increasing the meter size, the water supply could be increased to an adequate level. This approach was less costly than replacing the service entrance pipe or providing a pressure tank. The cost of the booster pump and new water meter was estimated to be $600 as opposed to a cost of $1,000 for replacing the service entrance pipe, $800 for installing a 400 gallon (total capacity) pressure tank (with the associated operating equipment), or $1,000 for installing a storage tank/pump combination.

- For existing construction, it was less expensive to change the water meter and provide a smaller booster pump than to attempt to offset the meter restriction by installing a larger pump. The cost of the smaller pump and new water meter was estimated to be $600 while the cost of the larger pump was estimated to be $900.

- In a rural residence, the cost of providing a booster pump, as a water supply source, is comparable to the cost of providing a pressure tank.

3-6.1.1.5 Each system was cost evaluated considering it to be installed by a contractor in new construction, by a contractor in existing construction and by the owner in existing construction. The approximate installed cost per sq. ft. for sprinkler protection in these example residences is shown on Table 3-6.1.1.5.

Sprinkler Protection - Single Family Residences
Installation Cost per Square Foot
(Table 3-6.1.1.5)

	Contractor Installed		Owner Installed	
USE	Level I	Level II	Level I	Level II
New - Urban	$0.65	$0.90	NA	NA
New - Rural	$0.85	$1.00	NA	NA
Existing - Urban	$1.10	$1.35	$0.35	$0.40
Existing - Rural	$1.10	$1.35	$0.35	$0.40

3-6.1.1.6 These cost estimates include a $10 building permit fee and the cost to prepare a schematic system drawing for obtaining the permit. It is assumed that local ordinances will allow the owner or installing contractor to prepare the drawings. If drawings are required to be sealed by an engineer, the cost of the owner-installed system will increase by approximately $0.10/sq. ft.

3-6.1.1.7 Labor represents approximately two-thirds of the contractor's cost for existing construction and approximately three-fourths of the cost for new construction. Existing construction has a larger material cost because of the need for a booster pump and a new water meter. Approximately 20% of the cost of a system in an existing residence is for concealing the piping within the finished spaces of the residence.

3-6.1.1.8 The cost of the owner installed system is primarily for material with the owner providing all of the work except for changing the water meter. That will have to be contracted through the water utility.

3-6.1.1.9 The system cost estimates were verified by having local plumbing contractors bid on system installation.

3-6.1.1.10 The individual system cost estimates are tabulated in the appendix.

3-6.1.2 Multiple Family Residences - Automatic Residential Sprinkler Systems

3-6.1.2.1 Level I and Level II automatic residential sprinkler systems using available technology and hardware installed in a multiple family residence were designed and cost evaluated. Each system was designed for a smaller, two bedroom apartment which has a protected area of approximately 600 sq. ft. (Example "D" - sketch appended). This apartment is typical of many which have been built in recent years.

3-6.1.2.2 The system design considered an available water supply immediately outside the apartment which was capable of supplying the sprinkler system. This supply could be either from a combination sprinkler/standpipe system with a sprinkler supply main located in the corridor, or from the domestic water system, which should be adequate in a larger apartment complex. The purpose of this example system is to evaluate the in-place cost of the sprinkler system piping located within the example apartment. It is assumed that there will be an adequate water supply available to the apartment from either the standpipe system or the domestic water supply system so that an additional water supply cost does not need to be incurred.

3-6.1.2.3 The approximated installed cost per square foot for sprinkler protection in this example apartment is shown on Table 3-6.1.2.3.

Sprinkler Protection - Multiple Family Residences
Installation Cost per Square Foot
(Excluding Water Supply)
(Table 3-6.1.2.3)

	Level I	Level II
New	$0.45	$0.75
Existing	$0.55	$1.15

3-6.1.2.4 The individual system cost estimates are tabulated in the appendix. The cost estimates are comparable to the estimates of the sprinkler system contractors who were interviewed (3-5.4.1).

3-6.1.3 Automatic Residential Halon 1301 Systems

3-6.1.3.1 The installation cost of an example total flooding residential Halon 1301 system which could produce a 5% concentration in Example Residence "C" was determined. That system will cost approximately $9,500 ($4.75 sq. ft.) in new construction and $11,000 ($5.50 sq. ft.) in existing construction.

3-6.1.3.2 Halon systems are a total flooding type system which must distribute agent throughout the protected volume as opposed to a sprinkler system which applies the agent over a predetermined area. A Halon system must discharge into a relatively tight enclosure in order to be effective, as must carbon dioxide and dry chemical systems.

3-6.1.3.3 The example system does not consider ventilation, room openings or the soaking period required for complete extinguishment of a deep seated fire. The cost of a system which considers those factors will be higher.

3-6.1.3.4 If the cost of the Halon 1301 agent is reduced to approximately $1 per lb., the cost of the system will decrease by approximately $500.

3-6.1.3.5 The cost analysis of the example system is appended.

3-6.1.4 Automatic Residential Carbon Dioxide System

3-6.1.4.1 The cost of a carbon dioxide system to protect the Example Residence "C" at a 50% carbon dioxide concentration is also approximately $9,000 ($4.50 sq. ft.) in new construction and $10,500 ($5.25 sq. ft.) in existing construction.

3-6.1.4.2 The cost analysis of the example system is appended.

3-6.1.5 Automatic Residential Multi-Purpose Dry Chemical System

3-6.1.5.1 The installation cost of protecting the Example Residence "C" with multi-purpose dry chemical at an application rate of 0.028 lbs. per cubic ft. is approximately $8,000 ($4.00 per sq. ft.) for new construction and $9,500 ($4.75 per sq. ft.) for existing construction.

3-3.12.5.2 The cost analysis of the example system is appended.

3-6.1.6 Automatic Residential High Expansion Foam System

3-6.1.6.1 The installation cost of protecting Example Residence "C" with high expansion foam applied at a fill rate of 4000 cfm (4 minute fill time) with foam ducted into each room is approximately $5,200 or $2.60 per sq. ft. for new construction and $6800 or $3.40 per sq. ft. for existing construction.

3-6.1.6.2 The high expansion foam system requires a larger water supply (30 gpm @ 100 psi) than does a sprinkler system.

3-6.1.6.3 The cost analysis of the example system is appended.

3-6.2 Installation Cost Comparison - Example Systems

3-6.2.1 The comparison of installation costs of the example systems when installed by a contractor in a new residence is shown on Table 3-6.2.

Example System Installation Costs
(Table 3-6.2)

Example System	Example Structure	Cost per sq. ft.
Automatic Sprinkler	"C" - Urban	$0.65
Automatic Sprinkler	"C" - Rural	$0.85
High Expansion Foam	"C" - Urban	$2.60
Halon 1301	"C" - Urban	$4.75
Carbon Dioxide	"C" - Urban	$4.50
Multipurpose Dry Chemical	"C" - Urban	$4.00

3-6.2.2 Because the installation cost of automatic residential Halon 1301 systems, carbon dioxide systems, dry chemical systems and high expansion foam systems are all considerably higher than sprinkler systems, sprinkler systems are considered the most economically promising type of automatic residential fire suppression systems. Their cost will be considered further on a "net" basis.

3-6.2.3 Interviews with potential system users have indicated that 20% of these potential users will install systems at a cost of $0.20 per sq. ft. or less (3-4.2.1).

3-6.3 Net Cost - Automatic Residential Sprinkler System

3-6.3.1 Definition/Purpose

Net cost is arbitrarily defined as the installed system cost with credits or debits amortized over a 20 year period at 8% compound interest. Net cost will be evaluated for both Level I and Level II systems installed in Example Residence "C" to illustrate how net cost can vary from installation cost.

3-6.3.2 Value - Example Residence "C"

3-3.14.2.1 The value of the example residence without a sprinkler system is set at $45,000 (including 60 foot wide, 10,000 sq. ft. lot) and the mortgage at $36,000 for this evaluation. The $45,000 residence value is the estimated 1976 median sale price of a new home based on extrapolation of data contained in Statistical Abstract of the United States (115).

3-6.3.3 Procedure

3-6.3.3.1 Sprinkler system cost studies were conducted for the following sets of circumstances:

- o New residence in new subdivision, contractor-installed system - Case 1.
- o New residence in existing community, contractor-installed system - Case 2.
- o Existing residence, contractor-installed system - Case 3.
- o Existing residence, owner-installed system - Case 4.

These results are broken down into installation costs and offsetting credits/debits and summarized to show a net cost in the following tables.

3-6.3.4 Installation Cost

The actual system cost includes the basic system cost less potential non-recurring credits for land use and frontage, where applicable (Table 3-6.3.4).

Actual System Cost
(Table 3-6.3.4)

	Level I System			
	Case 1	Case 2	Case 3	Case 4
Installation Cost (1)	$ 1190	$ 1190	$ 2095	$ 655
Land Use Credit (2)	(500)			
Frontage Credit (3)	(600)			
Actual System Cost	$ 90	$ 1190	$ 2095	$ 655

	Level II System			
	Case 1	Case 2	Case 3	Case 4
Installation Cost (1)	$ 1360	$ 1360	$ 2580	$ 735
Land Use Credit (2)	(500)			
Frontage Credit (3)	(600)			
Actual System Cost	$ 260	$ 1360	$ 2580	$ 735

(1) Example system costs appended (3-6.1.1.10).

(2) Assumes zoning ordinance will permit reduction in lot size(because of system use) to 9000 sq. ft. from 10,000 sq. ft., cost of land - $0.50/sq. ft.; $0.50/sq. ft. x 1000 sq. ft. = $500 (3-5.6.4.5).

(3) Assume zoning ordinance permits side yard reduction allowing lot width of 54' (rather than 60') because of system use; frontage cost (street, curbs, sewers, etc.) - $100/front foot; 6 front feet x $100/front foot = $600 (3-5.6.4.5, 3-5.7.3).

3-6.3.5 Annual Credits/Debits

Certain credits and debits may be available as shown on Table 3-6.3.5.

System Credits/Debits
(Table 3-6.3.5)

	Level I System				Level II System			
	Case 1	Case 2	Case 3	Case 4	Case 1	Case 2	Case 3	Case 4
Non-Deductible Items								
Reduced homeowners insurance premium (1)	38	38	38	38	38	38	38	38
Subtotal 1	38	38	38	38	38	38	38	38
Deductible Items								
Reduced mortgage interest (2)	18	18	--	--	18	18	--	--
Lost interest (3)	--	--	(168)	(52)	--	--	(206)	(59)
Reduced property taxes (4)	45	--	--	--	45	--	--	--
Increased property taxes (5)	(2)	(24)	(9)	(9)	(5)	(27)	(9)	(9)
Increased mortgage costs (6)	(7)	(95)	--	--	(21)	(109)	--	--
Subtotal 2	54	(101)	(177)	(61)	37	(118)	(215)	(68)
Federal income tax credit (7)	(11)	20	35	12	(7)	24	43	14
Annual Total (8)	81	(43)	(104)	(11)	68	(56)	(134)	(16)

(1) Assume full 25% credit (25% x $150 = $38) (3-5.2.1.2).
(2) 0.10% x $36,000 x 1/2 = $18 (3-5.2.3.3).
(3) Interest lost on cost of capital needed to purchase system - 8% interest
(4) Assume tax rate as 2% of market value except in Case 1 where rate of 1.9% is used due to increased density of land use (i.e. larger tax base). 0.1% x 45,000 = $45.
(5) Taxes increased due to increased cost of house (new) or increased value of house ($450 - existing) - (3-5.2.2.4).
(6) Increase due to increased cost of house - 8% mortgage rate.
(7) Assume 20% Federal income tax bracket - credit applied to Subtotal 2.
(8) Sum of Subtotal 1, 2 and Federal income tax credit.

3-6.3.6 Net System Cost

The net system cost is the actual system cost modified by the credit and debits as shown in Table 3-6.3.6.

Net System Cost
(Table 3-6.3.6)

	Level I System			
	Case 1	Case 2	Case 3	Case 4
Actual System Cost (1)	90	1190	2095	655
Increased Value of Residence (2)	(450)	(450)	(450)	(450)
Income from Annual Credit (3)	(3707)	--	--	--
Lost Income from Annual Debit (4)	--	1968	4760	504
Net System Cost	(4067)	2708	6405	709

	Level II System			
	Case 1	Case 2	Case 3	Case 4
Actual System Cost (1)	260	1360	2580	735
Increased Value of Residence (2)	(450)	(450)	(450)	(450)
Income from Annual Credit (3)	(3112)	--	--	--
Lost Income from Annual Debit (4)	--	2563	6132	732
Net System Cost	(3302)	3473	8262	1017

(1) (3-6.3.4).

(2) 1% of market value - $450 (3-5.2.2.4).

(3) Amount annual credit would produce after 20 years if invested at 8% compound interest.

(4) Amount annual debit would have produced after 20 years if it had been invested at 8% compound interest.

4-0 SYSTEM DESIGN CONSTRAINTS

4-0 SYSTEM DESIGN CONSTRAINTS

4-1 OBJECTIVE/APPROACH

4-1.1 Objective

The objective is to:

- o Establish design criteria for systems found to be capable of causing significant reduction in the National Residential Fire Loss (feasible systems).

- o Evaluate the ability of automatic residential fire suppression systems to reduce the National Residential Fire Loss

4-1.2 Approach

4-1.2.1 System evaluation

4-1.2.1.1 Using the data base developed and the Level I, II, and III systems which had been established, the probable impact on reduction of the National Residential Fire Loss was evaluated.

4-1.2.1.2 The ability of a system to:

- o Control fire

- o Limit side effects damage during the fire control process

- o Be accepted by the public

- o Be operable when called upon to react to fire,

will determine its ability to cause a reduction in the National Residential Fire Loss. A logic tree method of analysis was developed to objectively determine that reduction.

4-1.2.1.3 Two logic trees were developed, "Property Loss - Residential Fires" and "Injury - Residential Fires" (Figures 4-4 and 4-5), for the purpose of identifying the impact of an automatic suppression system on the National Residential Fire Loss.

4-1.2.1.4 The logic trees can be expanded to determine the impact of other factors affecting the National Residential Fire Loss such as:

- o Reducing the rate of fire incidence
- o Varying the fuel array within a residence
- o Varying the type of construction of the residence
- o Installing automatic fire detection devices in a residence
- o Varying fire fighting capability of a public fire department
- o Varying the fire fighting capability of the occupant

Such expansion is beyond the scope of this study.

4-1.2.2 System Design Criteria

The design criteria for automatic fire suppression systems which are deemed feasible by the logic tree method of analysis is presented in the format of an NFPA Standard.

4-2 DEFINITION OF LOGIC TREE TERMS

4-2.1 Damage

Damage is the sum of Fire Damage and Side Effects Damage.

4-2.2 Fire Damage

Fire Damage is a loss caused by direct burning or by contamination with "smoke" from an unsuppressed fire.

4-2.3 Side Effects Damage

Side Effects Damage is a loss caused by the subsequent fire control/ extinguishing process. Included is agent damage, fire department access damage, and damage caused by production of combustion products during the fire control/extinguishing process.

4-2.4 Probability of Limiting Damage

The probability of Damage being limited within the referenced boundary.

4-2.5 Probability of Limiting Fire Damage

The probability of Fire Damage being contained within the referenced boundary.

4-2.6 Probability of Limiting Side Effects Damage

The probability of Side Effects Damage being contained within the referenced boundary.

4-2.7 Reference Boundaries

4-2.7.1 Point of Origin

4-2.7.1.1 The Point of Origin is the fuel array in which fire originates.

4-2.7.1.2 Examples of Damage being limited to the Point of Origin are:

- o A short circuit in a television set which starts a small fire that burns itself out when the fuse blows, provided that smoke is not developed in sufficient quantity to damage other items in the room.

- o A frying pan fire which does not spread and which is put out before smoke causes damage to other items in the room.

- o A cigarette burn on a sofa which is put out before smoke causes damage to other items in the room.

4-2.7.1.3 A fire which is limited to the Point of Origin is a small fire, typical of the many unreported fires. This fire may burn itself out without spreading beyond the Point of Origin or may be controlled by the occupant.

4-2.7.2 Room of Origin

4-2.7.2.1 The Room of Origin is the room in which fire originates.

4-2.7.2.2 Examples of Damage being limited to the Room of Origin are:

- o A television set fire that produced enough smoke in the Room of Origin to require washing the walls and cleaning the furniture, rugs, draperies, etc. The fire would not necessarily spread beyond the television set in order to cause smoke damage to other items in the room.

- o A frying pan fire extinguished by a dry chemical extinguisher. The Fire Damage would be limited to the Point of Origin (i.e. the pan) but the Side Effects Damage would extend into the room because the dry chemical would have to be cleaned up. This would require washing the walls and vacuuming the dry chemical from cabinets, appliances, etc.

4-2.7.2.3 The fire which causes Damage extending beyond the Point of Origin, but limited to the Room of Origin will probably be a small fire in which the actual burning is limited to the Point of Origin. This fire is usually small and controllable by the occupant.

4-2.7.3 Unit of Origin

4-2.7.3.1 The Unit of Origin is defined as the living unit in which the fire originates. This includes all floor levels in a multiple level residence.

4-2.7.3.2 Examples of Damage being limited to the Unit of Origin are:

- o A fire in a fire resistive apartment building which has automatic door closers, smoke dampers and fire resistive separations between apartments. The fire may be large enough to cause flashover within the Room of Origin, but because of the presence of physical barriers, the fire and smoke would be confined to within the Unit of Origin.

- o A fire in an upper level bedroom in a multiple level dwelling unit. The smoke and discharge water from the fire department hose streams would cause damage on the lower level of the dwelling unit.

4-2.7.3.3 A fire which causes Damage which goes beyond the Room of Origin, but limited to within the Unit of Origin may be a relatively small fire which can be controlled by the occupant or it may be a larger fire requiring fire department response.

4-2.7.4 Building of Origin

4-2.7.4.1 The Building of Origin is defined as the building in which the fire originates.

4-2.7.4.2 Examples of Damage being limited to the Building of Origin are:

- A fire in a fire resistive multiple family residence in which the door to the apartment on fire was opened, allowing fire and smoke to enter the corridor and public areas of the building.

- A fire in an upper floor living unit of a sprinklered, masonry joisted, multiple family residence. The discharge water from sprinklers and hose streams would damage the contents on the lower floors as it leaked through the floors and ceilings.

4-2.7.4.3 The fire in which the Damage extends beyond the Unit of Origin, but is limited to within the Building of Origin may be either a large fire or a relatively small fire where smoke spread is great or where there is significant Side Effects Damage.

4-2.8 National Residential Fire Loss (Property)

The national annual direct property loss attributable to residential fire is defined as the National Residential Fire Loss (Property). This loss does not include:

- Maintenance of municipal fire departments
- Loss of property productivity or function
- Loss of taxes due to destruction of property
- Other contingent losses.

4-2.9 National Residential Fire Loss (Injury)

4-2.9.1 The cost of injuries attributable to residential fire is defined as the National Residential Fire Loss (Injury) and includes:

- Minor injuries such as simple burns, sprains and smoke inhalation.

- Major injuries such as severe burns and heart attacks.

- Rehabilitation of those injured by fire.

- Fatal injuries.

4-2.10 National Residential Fire Loss (Total)

The sum of the National Residential Fire Loss (Property) and the National Residential Fire Loss (Injury) is defined as the National Residential Fire Loss (Total).

4-2.11 Chart

A chart represents an individual element in the logic tree.

4-2.12 Curve

A curve is an individual graph on a chart.

4-2.13 Minimum Acceptable Performance Level (MAPL)

4-2.13.1 The term "MAPL" is used to describe automatic suppression system features evaluated in the 5.00 and 6.00 series charts.

4-2.13.2 The minimum acceptable performance level (MAPL) of a system feature is that which will provide a reasonable certainty of success; for example a 90% or higher probability of success in containing fire damage to the point of origin, as depicted by the individual charts.

4-2.14 Critical Maintenance

4-2.14.1 Critical maintenance is that which is necessary to ensure the functioning of an automatic suppression system.

4-2.14.2 An example of critical maintenance is maintaining the air pressure in a pressure tank. If the air pressure drops, there would be insufficient force behind the water in the pressure tank. Water would not discharge as needed from the opened sprinkler.

4-2.14.3 An example of non-critical maintenance is repacking a leaking valve stem, providing the leak did not cause Damage. If the valve leaks, the system can still function.

4-2.15 Level I Automatic Residential Sprinkler System

4-2.15.1 This system is essentially the minimum NFPA Standard #13D system which complies with the appended "Dwelling Sprinkler Standard" and consists of components performing at the MAPL.

4-2.15.2 The system essentially consists of:

- Density - 0.10 gpm/sq. ft. - one sprinkler operating; 0.05 gpm/sq. ft. - two sprinklers operating

- o Agent supply duration - 10 minutes
- o Simultaneous nozzle operating capability - two
- o Nozzle - extended coverage, sidewall or standard sprinkler
- o Actuation delay - dry pipe system
- o Detector - fusible link sprinkler
- o Sprinkler spacing - 256 sq. ft. maximum
- o Completeness - all occupiable spaces protected except small closets, hallways and baths
- o Component appearance - compatible with room decor
- o System life - 100 years minimum
- o Critical maintenance interval - 50 years minimum
- o Water supply - pump and tank - 250 gallon minimum
- o Supervision - none
- o False actuation rate - fusible link sprinkler

4-2.16 Level II Automatic Residential Sprinkler System

4-2.16.1 This system is a Level I system with improvements available using current technology and hardware.

4-2.16.2 The Level II system differs from a Level I system in these respects:

- o Agent supply duration - 30 minutes
- o Nozzle - standard sprinkler
- o Actuation delay - wet pipe system
- o Detector - "quick response" sprinkler
- o Completeness - all occupiable spaces
- o Water supply - municipal system
- o Supervision - local
- o False actuation rate - "quick response" sprinkler

4-2.17 Level III Automatic Residential Sprinkler System (Anticipated With Improved Technology)

4-2.17.1 This system is a Level II system with improvements created by better hardware.

4-2.17.2 The system differs from a Level II system in these respects:

- o Detector - "smoke" sensitive
- o Supervision - remote
- o False actuation rate - same as fusible link sprinkler

4-2.18 Automatic Residential Halon System

4-2.18.1 This system is currently available and has these characteristics:

- o Agent delivery rate - capable of producing 5% concentration within 10 seconds of discharge.
- o Agent supply duration - 10 minute soaking time.
- o Area of system operation - entire dwelling unit (total flooding system).
- o Nozzle - UL listed discharge nozzle
- o Actuation delay - none
- o Detector - "smoke" sensitive
- o Detector spacing - 400 sq. ft. maximum
- o Completeness - all occupiable spaces excluding closets, hallways and baths
- o Component appearance - compatible with room decor
- o System life - 100 year minimum
- o Critical maintenance interval - 5 years
- o Agent supply - stored pressure
- o False actuation rate - same as "smoke" detector

4-2.19 Carbon Dioxide System

4-2.19.1 This system is currently available and has these characteristics:

- o Agent delivery rate - capable of producing 50% design concentration within one minute of discharge
- o Area of system operation - entire dwelling unit (total flooding system)
- o Nozzle - UL listed discharge nozzle
- o Actuation delay - pre-discharge alarm
- o Detector - "smoke" sensitive
- o Detector spacing - 400 sq. ft. maximum
- o Completeness - all occupiable spaces excluding closets, hallways and baths
- o Component appearance - compatible with room decor
- o System life - 100 year minimum
- o Critical maintenance interval - 5 years
- o Agent supply - stored pressure
- o False actuation rate - same as "smoke" detector

4-2.20 High Expansion Foam

4-2.20.1 This system is currently available and has these characteristics:

- o Agent delivery rate - capable of filling protected volume within 5 minutes.
- o Agent supply duration - 15 minute operation time

- o Area of system operation - Entire dwelling unit (total flooding system)
- o Nozzle - UL listed discharge device
- o Actuation delay - pre-discharge alarm
- o Detector - "smoke" sensitive
- o Detector spacing - 400 sq. ft. maximum
- o Completeness - all occupiable spaces excluding closets, hallways and baths
- o Component appearance - compatible with room decor
- o System life - 100 year minimum
- o Critical maintenance interval - 5 years
- o Agent supply - Municipal water supply
- o False actuation rate - same as "smoke" detector

4-2.21 Multipurpose Dry Chemical System

4-2.21.1 This system is currently available and has these characteristics:

- o Agent delivery rate - capable of producing 0.028 lb/cu.ft. within 30 seconds of discharge
- o Area of system operation - entire dwelling unit (total flooding system)
- o Nozzle - UL listed discharge nozzle
- o Actuation delay - pre-discharge alarm
- o Detector - "smoke" sensitive
- o Detector spacing - 400 sq.ft. maximum
- o Completeness - all occupiable spaces excluding closets, hallways and baths
- o Component appearance - compatible with room decor
- o System life - 100 year minimum
- o Critical maintenance interval - 5 years
- o Agent supply - stored pressure
- o False actuation rate - same as "smoke" detector

4-3 LOGIC TREE ANALYSIS

4-3.1 Method of Analysis

4-3.1.1 The Logic Tree is a tool which is useful in:

- o Identifying how an individual input element of a system can impact on the system goal.
- o Establishing the cost/benefit relationships of the various solutions.
- o Identifying priorities among the various solutions.

4-3.1.2 This method of analysis can only be as accurate as the input data on which the individual curves and charts are based. While much of the input data is subjective and will be improved by more complete fire reporting procedures and fire research data, the method of analysis is still a useful tool in that it can be used to approximate:

- o The relative effectiveness of various types of automatic suppression systems.
- o The probable extent of the reduction in the National Residential Fire Loss caused by the use of automatic suppression systems.
- o The impact of automatic suppression systems when used in conjunction with other fire control, suppression and prevention systems.

4-3.1.3 The Logic Tree expresses the damage caused by residential fire to both people and property. The factors affecting fire severity and frequency are evaluated by the Tree as to the probability of each factor being able to limit fire development (Damage). Included in the evaluation are items dealing with both the ability and reliability of fire control systems.

4-3.1.4 The elements of the tree describing the various factors are combined through the mathematical process of "AND" or "OR" gates to arrive at the probability of all factors restricting fire damage.

4-3.1.5 When elements are combined through an "AND" gate, all elements are considered necessary for the success of the occurrence. The probability of success of the occurrence is determined by the formula:

$$P_t = P_1 \times P_2 \times \ldots \times P_n$$

Where:

P_1, P_2, P_n = Probability of success for each contributory element.

P_t = Probability of success of occurrence.

4-3.1.6 When elements are combined through an "OR" gate, the elements are considered independent of each other in terms of the success of the occurrence. The "OR" gate is always treated as an "AND/OR" gate. Elements may be combined through an "OR" gate to improve the probability of success of an occurrence. The probability of success of an occurrence is determined by the formula:

$$P_t = 1 - ((1 - P_1) \times (1 - P_2) \times \ldots (1 - P_n))$$

4-3.2 Damage Conversion

4-3.2.1 Use of the Tree and the associated curves to achieve a measure of the National Residential Fire Loss requires that the input statistics be converted to a cost basis at some level in the Tree.

In this study, this was done at the final steps "National Fire Loss - 1.0" and "National Injury Loss - 1.01". A more extensive study is needed to determine the lowest level of the Tree at which this conversion should occur to be fully valid. It is recognized that it may be as far down in the Tree as the "Fire Damage Limit - 5.10", "Suppression System Damage Limit (Side Effects) - 5.80, 5.60". The full development of these indexing factors was felt to be beyond the scope of this study because an adequate measure of the relative impact of suppression systems on the National Residential Fire Loss could be achieved without them.

4-3.3 Contributory Elements

The probability of success of each individual element of the logic tree is shown on the appended charts. Those probabilities were developed using the Residential Fire Record (3-2.1), Residential Fire Research (3-2.2) and data collected from interviews with potential system users.

4-3.4 Automatic Suppression Systems

The "branches" of the tree which deal with automatic suppression systems have been identified by the use of a heavy black

line. Those "branches" have been developed to the extent that a meaningful analysis of automatic residential suppression systems can be made. The "branches" can be developed further, particularly when additional input data (Fire Research and Fire Loss Experience) becomes available. Such further development is not feasible at this time as the available input data base is not accurate enough to support further refinement.

4-3.5 Alternative Fire Control Systems

The "branches" of the tree which do not deal directly with automatic suppression systems have been developed to the extent necessary to predict the National Residential Fire Loss. They may be expanded further to provide a more detailed analysis of their contributory elements. Such an analysis is beyond the scope of this project.

4-3.6 Analysis Procedure

4-3.6.1 The five types of candidate systems were evaluated using the Logic Tree Analysis. Sprinkler systems were shown to be the type which could best impact on the National Residential Fire Loss.

4-3.6.2 Five variations of a sprinkler system were considered (3-3.1.2):

- o A Level I system was evaluated based upon the predicted voluntary user acceptance by 1990.
- o A Level I system was evaluated based upon complete use of the system in all new residential units by 1990.
- o A Level I system was evaluated based upon complete use of the system in all residential units by 1990.
- o A Level II system was evaluated based upon complete use of the system in all new residential units by 1990.
- o A Level III system was evaluated based upon complete use of the system in all new residential units by 1990.

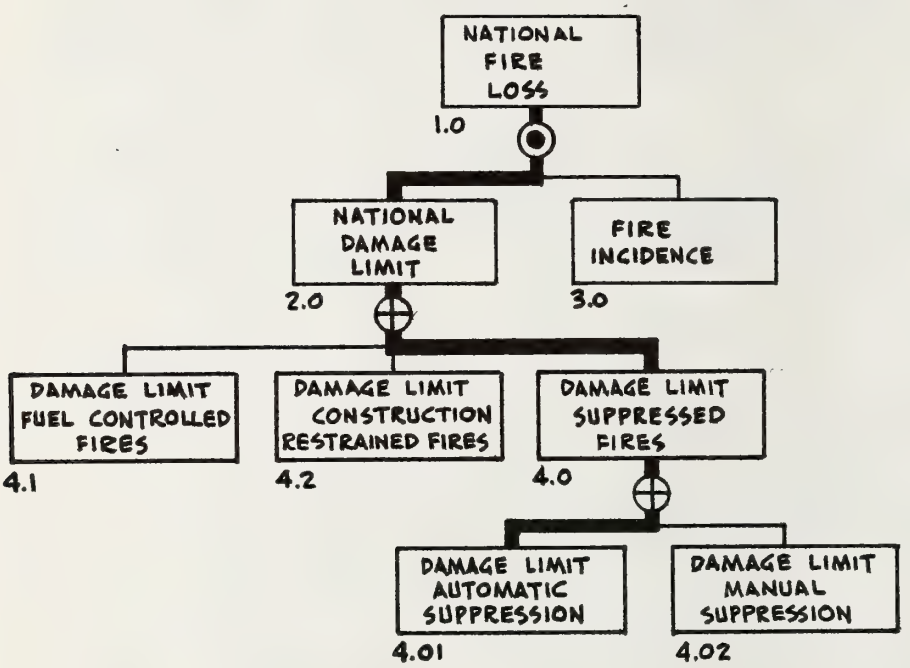
4-3.6.3 The impact of complete protection of all residential units by sprinkler systems was evaluated in order to determine if automatic sprinkler systems can theoretically meet the goal of 50% reduction in the National Residential Fire Loss

by 1990. *This goal can be met by complete use of Level I automatic sprinkler systems in all residences.*

4-4 PROPERTY LOSS - RESIDENTIAL FIRES

4-4.1 Discussion

4-4.1.1 This part of the Logic Tree and its related charts provide a means of expressing the National Residential Fire Loss (Property). The National Residential Fire Loss (Property) is directly related to the rate of fire incidence and the probability of limiting damage. The probability of limiting damage is related to the probability of damage limited by available fuel, by construction, or by suppression. Suppressed fires include fires suppressed by automatic systems and fires which are manually suppressed.



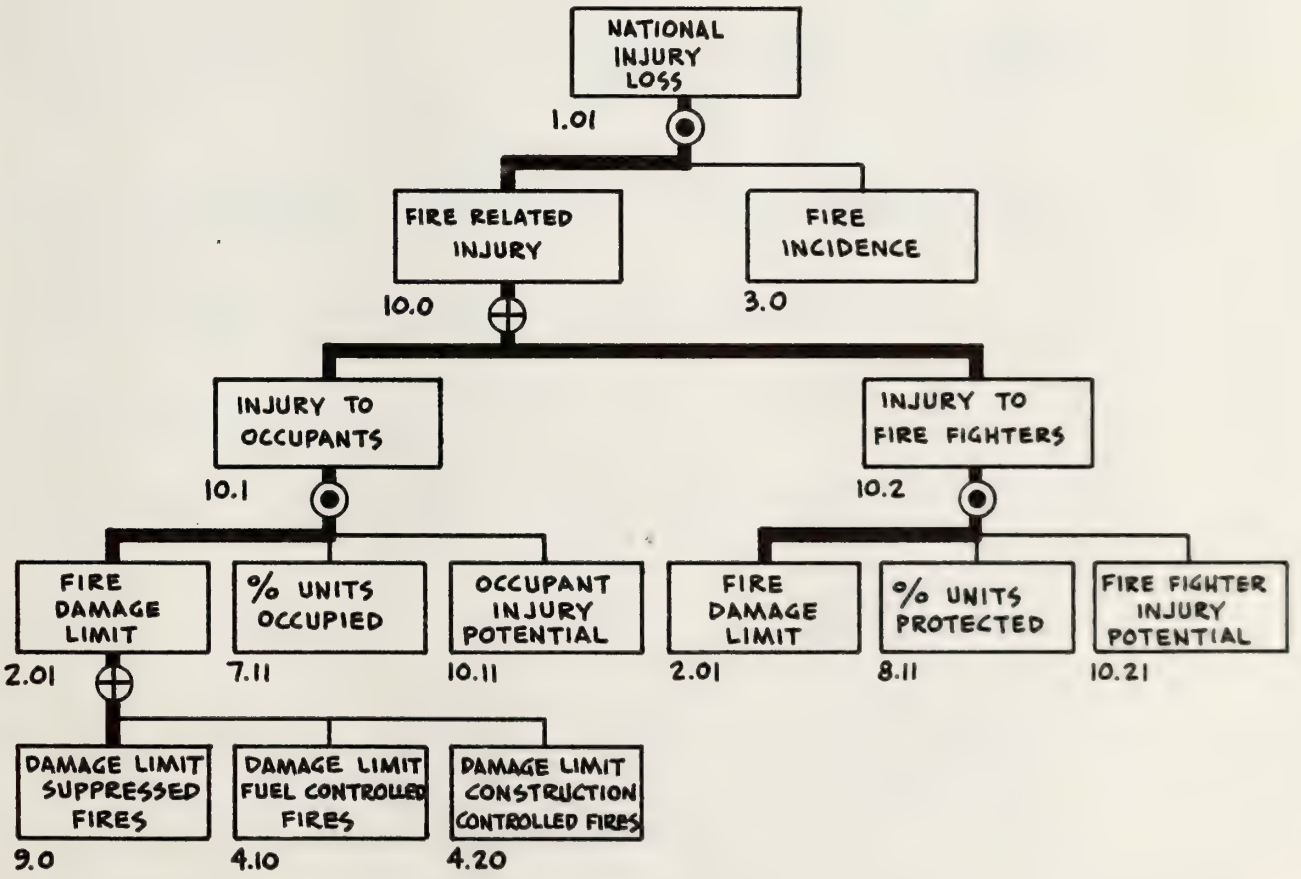
4-4.1.2 This Logic Tree was used to determine the extent to which automatic suppression systems can reduce the National Residential Fire Loss (Property). To do this, the 1990 National Residential Fire Loss (Property) was predicted, assuming that no automatic suppression systems would be used (i.e. Chart 4.01 - Damage Limit Automatic Suppression would not be used). The estimated impact of various automatic suppression systems was then projected through the Logic Tree and compared with the 1990 predicted "no system" loss.

4-4.1.3 The Logic Tree, a discussion of the elements which comprise the Logic Tree and the charts corresponding to each element of the Logic Tree are appended.

4-5 INJURY - RESIDENTIAL FIRES

4-5.1 Discussion

4-5.1.1 This section of the Logic Tree and its related charts provides a means of expressing the National Residential Fire Loss (Injury). The National Residential Fire Loss (Injury) is directly related to the rate of fire incidence and the probability of injury. The probability of injury is related to the probability of damage, the injury potential of the occupant or fire fighter, and the percent of residential units which are expected to have people in them (i.e., occupied units or units protected by fire department). The probability of damage is related to the probability of damage being limited by available fuel, by construction or by suppression as it was in the Property Damage Logic Tree.



4-5.1.2 The purpose of this Logic Tree is to determine the impact of automatic suppression systems on the National Residential Fire Loss (Injury). To do this, the National Residential Fire Loss (Injury) for 1990 was predicted assuming that no automatic residential suppression systems would be used. The impact of automatic suppression systems was then projected through the Logic Tree and compared with the 1990 "No System" loss.

4-5.1.3 The Logic Tree, a discussion of the elements which comprise the Logic Tree and the corresponding charts are appended. Because many of the elements found in the Property Damage Logic Tree are also found in the Injury Logic Tree, the discussion will be limited to those elements unique to the Injury Logic Tree.

4-6 SYSTEM IMPACT - 1990

4-6.1 Property Loss Reduction

4-6.1.1 Analysis Method

4-6.1.1.1 The curves of Chart 1.0 predict the number of fires which will occur within defined limits of property damage. Because the total number of fires (Chart 3.0) is held constant, a severity factor must be introduced to account for the differences in damages represented by each curve. To do this, a dollar loss was assigned for each level of damage:

Damage Limit: Less Than	- But - Beyond	Assigned Loss
Point of Origin	-	$25
Room of Origin	Point of origin	$300
Unit of Origin	Room of origin	$3000
Building of Origin	Unit of origin	$50,000

4-6.1.1.2 These assigned dollar losses are judgment decisions based upon available fire loss records and estimated repair/replacement costs.

4-6.1.1.3 All assigned dollar losses are based on current dollar value, as are all system costs.

4-6.1.2 Assigned Property Loss

4-6.1.2.1 The assigned 1990 Property Loss for each curve on Chart 1.00, as expressed by this method of analysis, is:

Curve	System	Assigned Property Loss
I	No System	$ 1,130,270,000
II	Level I - Voluntary	1,076,415,000
III	Level I - All new residences	1,009,480,000
IV	Level I - All residences	825,707,500
V	Level II - All new residences	986,272,500
VI	Level III- All new residences	981,450,000

4-6.1.2.2 The assigned loss calculations are appended.

4-7.1.2.3 The assigned "No system" loss of 1.13 billion dollars is consistent with the actual 1974 reported property loss (3-2.1.4).

4-6.2 Injury Loss Reduction

4-6.2.1 Analysis Method

4-6.2.1.1 The curves on Chart 1.01 predict the number of injuries which will occur in 1990.

4-6.2.1.2 In order to establish a cost basis for evaluation of the impact of injuries, four categories of injury severity have been defined and a per injury cost (current dollar value) has been assigned to each injury category:

Negligible Injury - is defined as an injury which does not require hospitalization. The assigned cost for this injury category is $25, based on minimal medical treatment, no loss of wages and no rehabilitation expenses. This type of injury is considered minor, usually not reported.

Moderate Injury - is defined as one which will require hospitalization as an in-patient for a maximum duration of 4 days. The assigned cost of this injury category is $2,000, based on estimated medical expenses for an average of three days hospitalization ($750), lost wages for ten days ($500) and moderate rehabilitation/out-patient expense ($750).

Serious Injury - is defined as one which requires hospitalization for a period exceeding 4 days. The assigned cost of this injury category is $100,000. The assigned cost considers the medical expenses for an average of 60 days hospitalization ($15,000), lost wages for 120 days ($6,000) and major rehabilitation/ out-patient expenses ($79,000).

Fatal Injury - is defined as one which includes all injuries in which the fatality is the direct result of the fire or action taken in response to the fire. The assigned cost of this injury category is $1,000,000. The assigned cost considers the average contribution of a productive individual to the National Product, as reported in the Statistical Abstract of the United States (115).

4-6.2.1.3 The severity of injury is assumed to be related to the extent of fire damage. The distribution of injury severity is assigned as shown on Table 4-6.2.1.3.

Distribution of Injury Severity
(Table 4-6.2.1.3)

Fire Damage Limit	Negligible Injury	Moderate Injury	Serious Injury	Fatal Injury	Total
Damage limited to point of origin	99%	0.74%	0.25%	0.01%	100%
Damage extending beyond point, but limited to room of origin	70%	20%	5%	5%	100%
Damage extending beyond room, but limited to unit of origin	10%	10%	40%	40%	100%
Damage extending beyond unit, but limited to building of origin	10%	10%	40%	40%	100%

4-6.2.2 - Assigned Injury Loss

4-6.2.2.1 The assigned 1990 injury loss predicted using this method of analysis, is shown on Table 4-6.2.2.

Assigned Loss
(Table 4-6.2.2)

Curve	System	Fatalities	Serious Injuries	Cost
I	No system	6241	6520	$6,932,348,775
II	Level I-voluntary	5522	5803	6,138,824,450
III	Level I-All new residences	4882	5166	5,432,347,100
IV	Level I-All residences	2847	3142	3,186,901,325
V	Level II - All new residences	4262	4554	4,746,079,400
VI	Level III - all new residences	3902	4195	4,348,758,050

4-6.2.2.2 The assigned loss calculations are appended.

4-6.2.2.3 While exact injury loss experience is not available, the injury losses predicted by this method of analysis are consistent with estimated injury loss experience (3-2.1.3).

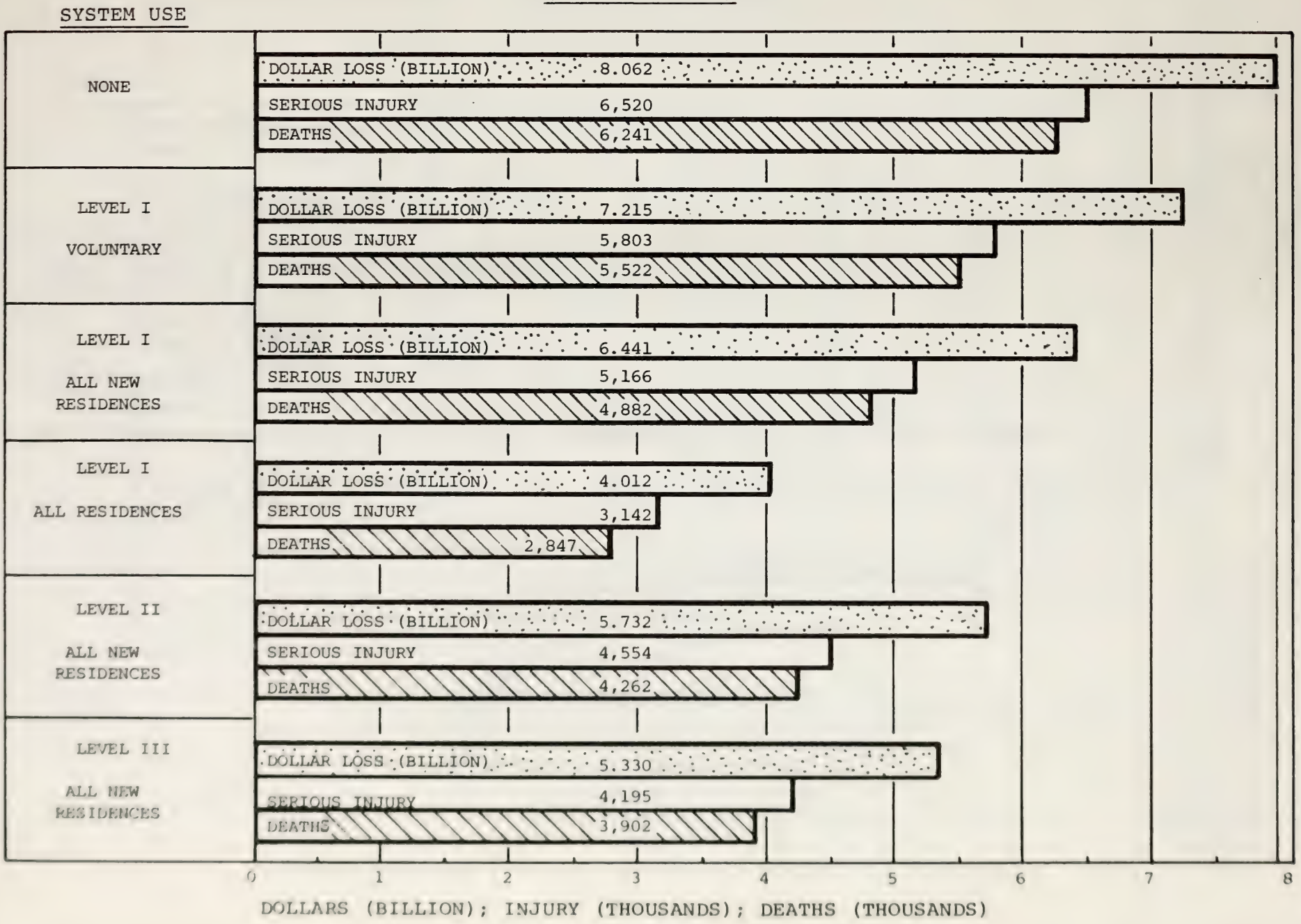
4-6.3 Assigned Loss Reduction

4-6.3.1 Assigned Losses

The total assigned loss for each condition represented on Charts 1.00 and 1.01 are shown on Table 4-6.3.1.

ASSIGNED RESIDENTIAL FIRE LOSS (1990)

(Table 4-6.3.1)



4-6.3.2 Loss Reduction

The assigned loss reduction caused by automatic suppression systems is shown on Tables 4-6.3.2A and 4-6.3.2B

ANNUAL LOSS REDUCTION

(Table 4-6.3.2-A)

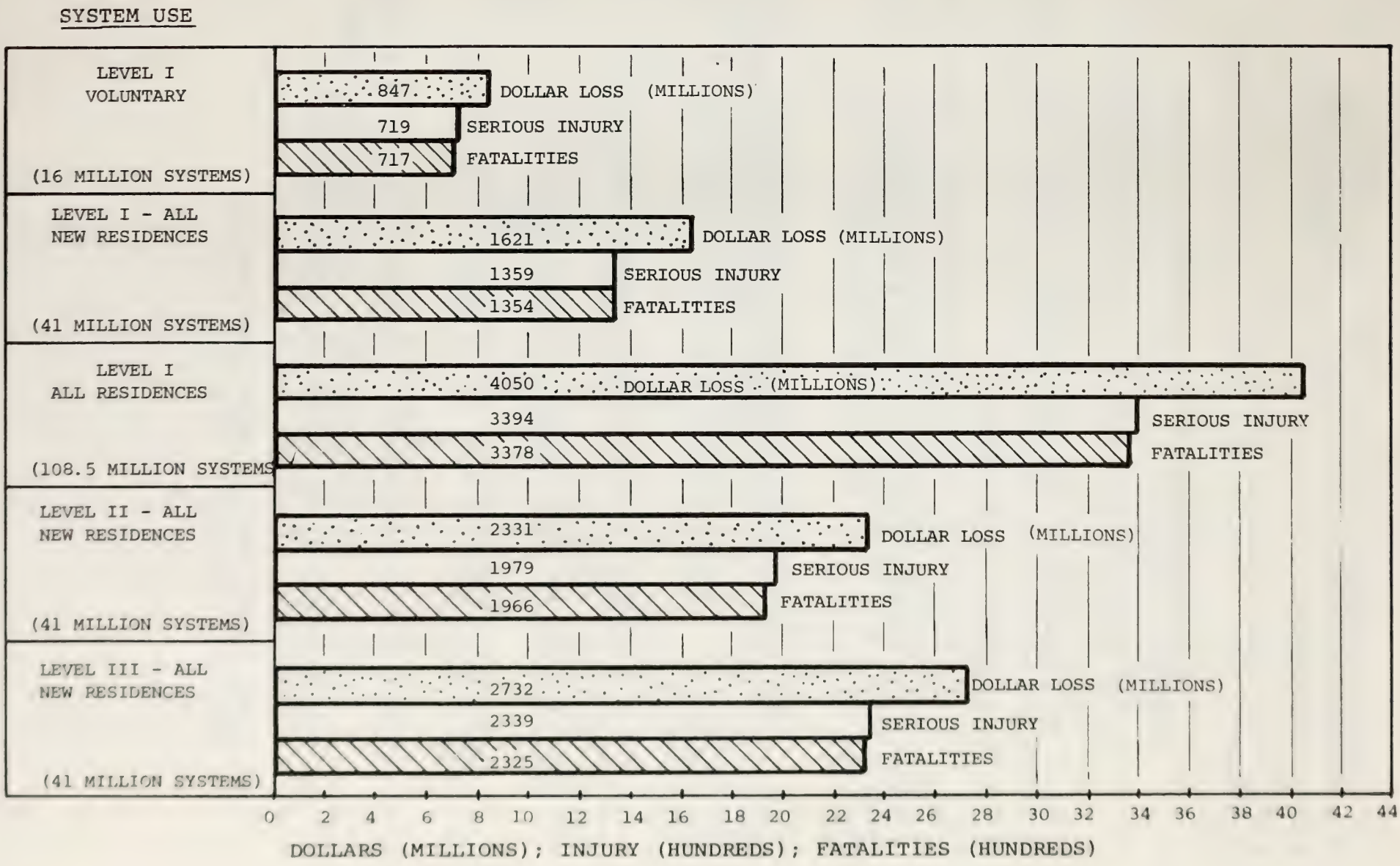
System Use	*No. of Systems	Dollars			Serious Injuries		Fatalities		% of Residences with Systems
		**Act.	%	Per Sys.	Act.	%	Act.	%	
Level I - Voluntary	16	$ 847	10.5	$53	719	11.5	717	11.0	14.74
Level I - All new residences	41	1621	20.1	40	1359	21.8	1354	20.8	37.78
Level I - All residences	108.5	4050	50.2	37	3394	54.4	3378	51.8	100
Level II - All new residences	41	2331	28.9	57	1979	31.7	1966	30.2	37.78
Level III - All new residences	41	2732	33.9	67	2339	37.5	2325	35.7	37.78

* Millions of systems

** Millions of dollars

ANNUAL LOSS REDUCTION

(Table 4-6.3.2-B)



4-7 SYSTEM SELECTION

4-7.1 System Types

4-7.1.1 Two types of systems have been selected for application:

- o A "Dwelling" Sprinkler System as described in the appendix.
- o A "Standard" Sprinkler System as described in NFPA 13 - 1976 and NFPA 14 - 1976, modified as recommended.

4-7.1.2 Both of these systems are available with existing hardware.

4-7.2 "Dwelling" Sprinkler System

4-7.2.1 A "Dwelling" Sprinkler System is limited to use in single family dwellings and the living/circulation areas of some multiple family residences. Such a system is not equipped with a fire department connection. The system is analogous to and may be an extension of the domestic cold water distribution system.

4-7.2.2 NFPA Standard #13D "Standard for Installation of Sprinkler Systems in One and Two Family Dwellings and Mobile Homes", 1975 Edition, presents design criteria for this type of system. Standard #13D has been used as the basis for creating the appended "Dwelling" Sprinkler System design standard.

4-7.2.3 The "Dwelling" Sprinkler System Design Standard describes available systems. As new technology is used to develop new system components or methods, the standard may need to be changed to recognize technological advances.

4-7.2.4 The "Dwelling" Sprinkler System may be used in multi-family housing as outlined in the appended "Dwelling" Sprinkler Standard.

4-7.3 "Standard" Sprinkler System

4-7.3.1 A "standard" sprinkler system or a sprinkler/standpipe system (a combination system as defined by NFPA Standards #13 and #14) is needed in those multiple family residential buildings which have:

- o Common areas, service areas, and storage areas over 300 sq. ft. in area

- OR -

- o Undivided, inaccessible attics or concealed spaces with areas in excess of the plan view area of an individual living unit.

- OR -

- o Commercial occupancies

4-7.3.2 In such buildings, the water supply needed to protect the non-residential areas or supply the standpipe system exceeds that needed for the residential portions of the building.

4-7.3.3 Such sprinkler systems or a sprinkler/standpipe system need a fire department connection. All portions of the system must be capable of withstanding the imposition of pressure through the fire department connection.

4-7.4 Design Standard Modifications

4-7.4.1 The modifications to NFPA Standards #13, 13D, and #14 needed to properly define the selected systems are:

4-7.4.2 Modifications - NFPA Standard #13, Installation of Sprinkler Systems, 1976 Edition

Add "exception" to Section 8-4.4 (Standard 13):

> EXCEPTION: In light hazard apartment buildings, the total installed supply shall be a minimum of 250 gpm. Calculated sprinkler system demand need not be added to this supply

4-7.4.3 Modifications - NFPA Standard #13D, Sprinkler Systems - One and Two Family Dwellings - 1975 Edition

This material is contained in the appended design standard.

4-7.4.4 Modifications - NFPA Standard #14, Standpipe and Hose Systems, 1976 edition

4-7.4.4.1 Add exception to Section 1-8.3:

> EXCEPTION: The minimum installed water supply for a combined system in a light hazard high rise apartment building shall be 250 gpm.

4-7.4.4.2 Add "Section 5-6, Minimum Supply for Combined Systems" and renumber existing "Section 5-6, Fire Department Connections" to 5-7, "Fire Department Connections":

5-6 Minimum Water Supply for Combined Systems.

5-6.1 The minimum water supply for a combined system in a partially sprinklered building shall be the same as the minimum supply for Class I service.

5-6.2 The minimum water supply for a combined system in a light hazard completely sprinklered high rise building shall be 500 gpm.

EXCEPTION: The minimum installed water supply in a completely sprinklered light hazard high rise apartment building shall be 250 gpm.

5-6.3 The minimum water supply for other types of high rise buildings shall be 1,000 gpm.

5-6.4 The minimum installed water supply for other types of buildings shall be in accordance with Table 5-6.4.

Table 5-6.4

Minimum Water Supply

Hazard Classification	Sprinklers (GPM)	Combined Inside & Outside Hose (GPM)	Duration in Minutes
Light	150	100	30
Ordinary Group 1	400	250	*60-90
Ordinary Group 2	600	250	*60-90
Ordinary Group 3	750	500	*60-120

NOTE: The lower duration figure is ordinarily acceptable where a remote station waterflow alarm service or equivalent is provided.

5-0 NEW CONCEPTS

5.0 NEW CONCEPTS

5-1 OBJECTIVE/APPROACH

5-1.1 The objective was to:

- Determine how the selected systems can be improved to better meet the User Requirements.
- Identify other systems which may be feasible with improved technology.

5-1.2 System hardware, marketing methods, cost and other consumer acceptance criteria were studied to suggest where improvements could be made.

5-1.3 The acceptability of automatic residential suppression systems is primarily affected by the cost of the system and the public awareness of its value.

5-1.4 The most important factors which will impact on cost reduction are:

- More efficient and less expensive system hardware
- Less expensive installation methods
- Improved extinguishing and detection capability
- Removal of installation restrictions

5-1.5 Public awareness is improved by knowledge of the character and value of the system including:

- Appearance
- Confidence in system ability
- Perception of need
- Understanding of function

5-2 SYSTEM COST

5-2.1 Existing Buildings

The most significant factor affecting cost and installation of residential suppression systems occurs in existing buildings. A system requiring breaking out ceilings, partitions, floors or other structural elements creates prohibitive cost and inconvenience factors. Exposed piping systems in finished areas are unacceptable to the user. It is, therefore, unlikely that systems will be installed in existing buildings unless this problem can be solved. The best solution to this problem is a "packaged system" which can ideally be installed as easily as hanging a picture on a wall.

5-2.2 Improved System Hardware

System components which are less expensive, easier to install or which increase system sensitivity/effectiveness with related savings in piping and agent supply, can be developed.

5-2.3 Piping Methods

5-2.3.1 The labor needed to install a system can be reduced by using a flexible pipe or tubing. In new construction, such tubing would reduce the necessity for careful measurement and coordination with the structure. This would make the installation easier and faster. In existing construction, there is a possibility that the tubing could be pulled through the walls in concealed spaces using a "fish tape".

5-2.3.2 The tubing must be capable of withstanding anticipated system pressure, must not be subject to crimping and must be able to withstand abrasion. The coupling method should permit fast, easy joint make-up. The connection to the nozzle should absorb the nozzle reaction so that the nozzle position will not change when the system activates.

5-2.4 Restrictive Regulation

Backflow preventers and meters add cost to the system and are detrimental to its operation. Rubber-faced check valves are an adequate backflow prevention device and are included in the "Dwelling" System Design Standard. Water flow alarms will indicate water usage from the system and should make the need for meters for this purpose unnecessary. The meter introduces excessive friction loss which affects cost signficantly. The waiving of permit fees seems appropriate in support of public safety.

5-3 IMPROVED PUBLIC ACCEPTANCE

5-3.1 Several factors influence the public acceptance of systems. A public information program and regulatory procedures are needed to improve the acceptance of systems.

5-3.2 The public needs to be made aware of the availability and desirability of automatic residential sprinkler systems if those systems are to be sold. A major public information program could create a public awareness of the fire problem and the ability of sprinklers to address that problem. This would develop an initial market for systems which will expand as system suppliers entered the market and advertised their products. Once the initial system demand is created, it should grow because of the influence of suppliers on the market much as the residential fire detector market has grown because of the advertising campaign of the numerous fire detector suppliers.

5-3.3 System appearance has been expressed as a concern of potential users. This problem appears to be somewhat overstated. A public information program should reduce public concern over system appearance by showing the public how system components can be either totally concealed or blended with the decor of the protected area. Examples of such available components which blend with the decor are:

- o Totally concealed sprinklers
- o Recessed, chrome-plated sprinklers
- o Small, unobtrusive sprinklers

Sprinkler manufacturers are presently developing unobtrusive sprinklers to meet the demand for such sprinklers in commercial buildings. This technology can logically spill over into the development of unobtrusive residential sprinklers.

5-3.4 Public concern about accidential system discharge appears to be a result of not understanding how a system works. There is a common misconception that sprinkler systems discharge accidentally rather frequently and that when a system discharges, all sprinklers on that system actuate. In reality, the leakage rate of sprinklers is approximately 1 per year for each 3,000,000 sprinklers. When a sprinkler operates accidentally or leaks, water discharges from that sprinkler only, not from the other sprinklers on the system. A public information program explaining how a system operates and its susceptibility to false operation should overcome the public concern about accidental system discharge.

5-3.5 An installation standard, such as the one proposed, is needed to provide minimum system performance criteria. Without control or minimum system performance, inadequate systems may be sold which will fail to operate properly during fire.

Failure of such systems could adversely affect future system use because the public will probably judge adequate systems based upon the failures of inadequate systems. If the public decides that the system value is suspect because of the failure of inadequate systems, the acceptance of systems could be seriously hindered.

5-4 NEW TECHNOLOGY

5-4.1 Goals

5-4.1.1 The sensitivity/effectiveness of a system needs to be improved so that the system will have the ability to:

- o Respond to a smoldering fire
- o Detect where fire occurs within a room
- o Aim the extinguishing agent at the fire
- o Shut off the agent flow when the fire danger is eliminated
- o Regulate the extinguishing agent flow rate to an optimum level

Such a system will:

- o Need a smaller water supply, tubing and nozzles so located or directed that the agent discharge will not be wasted on those parts of the room which are not involved in fire.
- o Reduce the system's Side Effects Damage because the agent will be discharged at the fire area and shut off when the fire danger is eliminated.
- o Control Fire Damage more effectively because the system will operate sooner.

Improved sensitivity/effectiveness may well be an important consideration in developing a "package system" which will, of necessity, have a relatively small water supply.

5-4.2 Component Development

System components designed for use specifically in a residential suppression system may reduce the overall system cost. Examples of such components include:

- o A low friction loss water meter, to eliminate the need for an oversized water meter.
- o A booster pump (possibly made of plastic) designed for residential use.
- o A water flow alarm device (possibly made of plastic) which will operate on differential pressure such as a Venturi tube or which will operate electrically.

- Valves designed for residential use (possibly with plastic working parts and bodies).

- Interfacing devices which will enable the telephone communication system to be easily used as a means of transmitting fire and supervisory alarms to the fire department or to a central supervisory location.

- Smaller, less conspicuous ceiling and side wall sprinklers.

- A concealed "on-off" sprinkler which is both smoke and heat sensitive

- Electronic detection or sensing element which will locate fire, activate a system, or a portion of a system, and indicate system operation without being interconnected with wiring or by multiplexing over house wiring.

5-4.3 Water Systems

Several different types of water systems may be feasible for use within a residence with improved technology. Such systems include:

- Individual, small packaged units containing water with an additive under pressure or with a pressure source, such as a carbon dioxide cylinder, discharging in a fog pattern, might be very effective in existing residences.

- A system with nozzles and detection mechanisms related to smaller areas of application (i.e., 25 sq. ft.) thereby reducing Side Effects Damage, tubing size and system cost.

- A system which ejects a fine water spray or "fog" at a limited number of locations allowing the convection currents of the fire to carry the "fog" into the fire. This type of system may be effective on larger fires, but presently appears to be ineffective on smaller fires.

- A system which uses perforated pipe or tubing located either at the ceiling or at the floor, that discharges a fine spray throughout the space, may be a feasible method of protection.

- A system of discharge nozzles mounted at the floor level discharging a fine spray upwards into the room may be more effective in controlling fire than ceiling mounted nozzles.

5-4.4 Halon Systems

5-4.4.1 A fast acting, local application halon system which employs a directional detection system and directional nozzles may be a feasible method of protecting existing residences. This system could be a package system which would be mass merchandised and easily installed either by the owner or the tenant in an existing residence.

5-4.4.2 A halon system supplied with an unlimited halon supply through a central utility company could be feasible. Such a system could be either a local application or a total flooding system.

5-5 NEW TECHNOLOGY - EXAMPLES

Several prototype systems and system components are discussed and illustrated in the appendix. These represent ideas for development. On the surface, some may not seem practical or feasible, but they are sufficiently worthy to be evaluated further.

5-6 NEW COMPONENT EVALUATION

5-6.1 New components and methods which are developed should be evaluated in accordance with the conditions of their intended use. Evaluation procedures should simulate the residential environment in which the component will function. Care is to be taken to match component performance ability to the demands placed upon it by residential fire and the residential environment. Excessive component performance safety factors tend to be self-defeating if, by increasing system cost, they reduce system use.

5-6.2 The Standard Residential Fire Test Procedure (2-4.10), which will simulate real world residential fire conditions, should be used as a part of the evaluation process.

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APPENDIX I

INTERVIEWS WITH GROUPS INFLUENCING SUPPRESSION SYSTEM USE

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APPENDIX I

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INTERVIEWS WITH GROUPS INFLUENCING SUPPRESSION SYSTEM USE

I.1 BACKGROUND

This appendix summarizes the detailed findings of the interviews with various groups and carries the initial reactions of the individuals to the selected residential fire suppression system.

Prior to each interview, the origin of the National Fire Prevention and Control Administration resulting from the report "America Burning" was explained. It was indicated that one of the goals of the National Fire Prevention and Control Administration is a 50% reduction in both life loss and property damage in residential occupancies by 1990. In an effort to achieve this goal, various contracts are presently under way to investigate and to develop a low cost residential fire suppression system. The design parameters of a basic low cost residential fire suppression system were then discussed.

In general, most groups were not familiar with the availability of NFPA 13D. The initial orientation of the interviews consisted of an explanation of 13D, the system definition which modifies this standard and also the scope of this study. The existence of this standard and our expansion of the consideration for larger units and for modification of the protection provided by the systems were explained.

I-2 INTERVIEWS WITH INSURANCE INTERSTS

I-2.1 Summary

Interviews were conducted with major insurance companies dealing with residential insurance.

The responses indicated that under the present homeowners insurance policy rate structure approximately 30% to 50%, depending upon source, is devoted to the premium necessary for fire insurance protection. One insurance company and the Insurance Services Office is providing approximately 2% rate credit for the installation of approved smoke detection systems. ISO has established a schedule of credit for residential fire protection improvements and these would reflect a possible credit of up to 5% for the installation of a sprinkler system covering all areas of the dwelling and a possible additional 5% for the installation of an approved remote station alarm-type system connected to the sprinkler system.

The insurance companies interviewed indicated that due to the basic low premium volume per individual policy, the ability to provide detailed engineering or underwriting efforts would be a responsibility of the agent.

The companies indicated that their main thrust of insurance coverage in these areas is on a volume basis and little concern is appropriated to the amount of coverage given in most urban areas. They indicated a concern for possible high value coverage in rural areas that would warrant more underwriting expertise than they typically provide.

All companies expressed the feeling that should the experience and history of losses incurred with such systems be markedly different from their expectations, that they would reflect these changes in their rating and underwriting structures.

The reaction of most companies with reference to multi-family dwellings would be that the "modified" system as discussed would possibly receive rate credit but the credit extended would be substantially less than that provided with the installation of a standard NFPA 13 sprinkler system.

I-2.2 INTERVIEW WITH INSURANCE COMPANY "A" - December 27, 1976

One and Two Family Dwellings - Owner Occupied

Approximately 30% to 40% of overall losses covered under Home Owners Insurance policies are attributable to fire. The remainder of the losses are the result of other perils covered under the standard Home Owners policy. Approximately 30% to 40% of the rate is related to the fire peril.

Insurance Company "A" to date has not given any credit for installation of fire detectors within the home. There is a degree of concern with regard to proper installation and maintenance of the devices.

The possible effects of detector installations on losses are unclear. No statistics are presently available as to the number of fires occurring when the dwelling is occupied versus fires occurring when the dwelling is not occupied (Insurance Company "A" statistics). There is some question as to action which would be taken by the owner in occupied dwellings. The number of fires which would be detected by the owner himself versus those which would be detected by an installed detector must be determined. The action the owner would take in an attempt to extinguish the fire, notify the fire department, or merely evacuate must be answered. All of these factors impact the possible degree of loss reduction, and, as a result, create a reluctance to grant any insurance credits for detectors only.

The installation of an automatic suppression system has not been considered from either a rating or underwriting standpoint. The insurance company must evaluate damage from a fire suppression system; damage created by a fire department; fire damage itself to determine overall experience and any possible rate changes.

Concern was expressed with regard to water supplies. Would a 10 minute water supply be adequate when fire department response could be guaranteed within the 10 minutes, probably through direct alarms to the fire department assuming fire department running times in the five minute range? It is possible that a credit might apply only to systems with longer duration water supplies.

It would not be possible to have gradations between types of systems. A credit might be applied for a system judged to be minimally acceptable to the insurance company; no additional credit would be available if the system were improved. The overall credit available must necessarily be less than anticipated with a standard (NFPA 13) system, a system with an unlimited water supply, or a system covering all areas of the building.

It is possible that a slight credit might be applied to the rate if system alarms were directly connected to the fire department.

A 10% to 15% reduction in overall home owners rates is possible through the installation of a low cost residential fire suppression system.

Multi-Family Dwellings - Building Insurance

The effect of a residential system on building insurance in a multi-family residential occupancy would be approximately the same as for a one and two family dwelling. A standard (NFPA 13) system would produce a greater rate credit. Magnitude of the difference could not be determined.

Non-Owner Occupied Dwelling

Insurance coverage for the contents of non-owner occupied dwelling is usually under a renter's policy. Approximately 15% of the losses under such policies are attributable to fire. The maximum credit available, therefore, would not exceed 5% if a residential suppression system were installed.

Underwriting Considerations

Installation of a residential suppression system would not by itself make an uninsurable dwelling insurable. A number of factors determine the insurability of the dwelling, including its overall repair and condition, exterior fire exposures (the proximity of exterior fire sources or other buildings), availability of adequate fire protection water supplies, availability of adequate fire department response, etc. Installation of such systems in an entire development would make that development considerably more attractive from an underwriting standpoint and would probably increase the limits of insurance an individual company would be willing to write on the development. Installation of a suppression system in a building considered uninsurable due to lack of fire department response might make the building insurable assuming an adequate water supply is available. Concern was expressed as to the certification of a system, installation of approved devices and inspection of the system to assure that it is operative.

I-2.3 INTERVIEW WITH INSURANCE COMPANY "B" - December 30, 1976

One and Two Family Dwellings - Owner and Non-Owner Occupied

Insurance Company "B" writes very few policies in this category therefore, an in-depth discussion was not carried on.

Multi-Family Dwellings - Building Insurance

The major cause of large losses is related to lack of compartmentalization (attic spaces, overhanging eaves and soffits, mansards, and similar structures) as well as deficiencies in design and improper use of building materials.

To accomplish the installation of residential suppression systems, the apathy of builders and developers toward fire and fire loss must be overcome. It will probably be necessary to legislate the installation of systems due to this overall apathy and reluctance on the part of builders or developers to commit funds for loss prevention.

A residential sprinkler system involving "partial" protection (sprinklers omitted in closets, bathrooms, and similar areas), would result in minimal, if any, credit. It would be necessary that each individual building be evaluated with regard to its construction, compartmentalization, as well as the anticipated impact of a limited water supply, partial system.

If a standard sprinkler system were installed, it would again be necessary to individually evaluate each structure to determine the rate credit. The magnitude of credit would be dependent upon design considerations involving water supplies. Minimal credit would be given on limited water supplies and normal commercial credit as the supplies approach NFPA 13 standard levels.

From an underwriting standpoint, installation of a standard (NFPA 13) system would improve the acceptability of a multi-family building in outlying areas.

Very little data is presently available, thus, rate credits would be on a judgment basis until such time as actuarial data is developed.

I-2.4 INTERVIEW WITH INSURANCE COMPANY "C" - December 27, 1976

One and Two Family Dwellings - Owner Occupied

The matter of installed fire protection systems, either alarm or suppression systems, was discussed by a committee and a sub-committee of Insurance Company "C"'s office in July, 1976. This discussion resulted in the guidelines to be followed by the insuring companies:

> Installation of approved, properly maintained central station fire alarm or burglar alarm system - Credit up to 5%.
>
> Installation of approved and properly maintained remote station fire alarm or burglar alarm system - Credit up to 3%.
>
> Installation of approved local fire alarm or burglar alarm system - credit up to 2%.
>
> Installation of approved and properly maintained automatic sprinkler system covering all areas in the dwelling - Credit up to 5%.
>
> Installation of approved automatic sprinkler system covering all areas with the exception of bathrooms, closets, attached garages, porches, etc., with heat detectors installed in all areas not protected by automatic sprinklers - Credit up to 2%.

The credit to be given is at the discretion of the insuring company.

The credit for automatic sprinklers would be the same whether an NFPA 13 or NFPA 13D system were installed.

These credits do not apply to mobile homes.

Insurance Company "C" will not review, inspect, or otherwise service the dwelling sprinkler systems.

The credits for a central station burglar and fire alarm system are cumulative as are the credits for remote station burglar and fire alarm. For example, in the event sprinklers were installed and the waterflow alarm was connected to an approved central station, a total credit of up to 10% would be applicable. Credits for local burglar and fire alarms are not cumulative and would be limited to 2%.

Multi-Family Dwellings - Building Insurance

This type of structure is class rated. Credits would be established by the individual Insurance Compañay "C"'s office by application of commercial insurance rating schedules. These credits would then be recommended to the insuring company who would use the credits at their discretion.

Renter's Insurance

Policies written as a contents only Home Owners Policy would be subject to the same credits applicable to one and two family owner occupied dwellings.

I-3 INTERVIEWS WITH BUILDERS

I-3.1 Summary

Interviews were conducted with three home builders. Concern was expressed for both the cost and appearance of the system. An Association indicated that the rising cost of individual family ownership was such that the market was restricted to a limited segment of the American population. If the installation of such a system were to be required, the additional cost of such a system could further restrict the ability of the American individual to procure his own home.

Builders feel that improved fire protection must be educationally encouraged. People need to be exposed to the consideration of fire protection on a much broader basis than 1 week per year. This education should not only consist of what to do in the event of emergency situations but also the necessary considerations for proper "living characteristics" in both single and multiple family residential properties. Individuals must be educated to understand that their actions can contribute to the spread or containment of fire and to the exposure they will encounter in the event of a fire in their property.

Indications of an Association are that construction will progress at a rate of 2 to 2-1/2 million units per year between now and 1990. New factors will reflect what type of construction these units will be. Consideration for energy will alter the configuration of the house, the materials involved, the heating and insulation systems of the structure along with considerations for space limitations. The advent of government housing programs will foster an effect on the overall construction business i.e., government programs such as low cost and public housing along with government subsidized loan programs.

The selling point of a fire suppression system would have to be its protective features; it would be difficult to create a positive selling atmosphere for this system. A negative sales atmosphere would be detrimental to the overall selling characteristics of the traditional home builder.

Some people are no longer buying a minimal house but are adding luxuries to it in terms of air conditioning, carpeting, appliances, etc. The cost of the system would reflect the owners ability to choose from the various options available and it was felt that in most instances it would be a low priority consideration to the prospective buyer. In the luxury home market, especially in remote suburban areas, the acceptance of the system would be greater than in the typical urban and lower cost housing areas.

A cost level of under $1,000 per unit would probably be accepted by the people buying the medium priced home as an improved protection characteristic.

If the cost of the house could be reduced by an amount equal to the cost of the installation, they would market this as a positive feature and build it into the base price of the home.

I-3.2 INTERVIEW WITH HOME BUILDER "A" - November 30, 1976

General

Home Builder "A" indicated that they had encountered local authorities who are requiring sprinkler protection in single family dwellings. These local authorities are in small communities with a rather limited degree of technical knowledge.

The fire suppression community has not succeeded in educating the general public to the advantages of fire suppression systems whereas the mass marketing approach of the detection industry has resulted in overall wide acceptance.

One and Two Family Dwellings - Owner Occupied

A suppression system would be a plus factor from a marketing standpoint. Such systems speak to the conservation of both material and people. The public is conscious of changes in technology which improve their overall standard of living therefore, a positive approach is available from a sales standpoint. Emphasis should be on the saving of lives as well as the saving of property. It should be pointed out that regardless of insurance coverage, the homeowner never fully recovers from a serious fire loss.

Construction of the system must be good in order for the system to have a proper degree of reliability. Tubing should not be crimped around corners, etc. There are instances where 1" garden hose connections have been provided as portable fire extinguishers in some single family dwellings.

Multi-Family Dwellings

A fire suppression system would be acceptable to many more people than the presently mandated detection systems. This is due to problems with false alarms or the activation of the detectors. However, code trade-offs need to be almost mandatory to reduce net costs and thereby make a suppression system acceptable on a cost basis.

I-3.3 INTERVIEW WITH HOME BUILDER "B" - January 19, 1977

Home Builder "B" is familiar with the concept of Residential Fire Suppession Systems.

Approximately 1.7 to 2 million units will be built per year over the next 30 years. This could vary as the economy or the configuration of housing varies.

Based upon a 13D System and considering some variations, the cost of installation would be approximately $600 to $1,200 per unit. The cost at the start of installation would be higher due to unfamiliarity with the installation. A plumber would be unfamiliar with methods of installing sprinklers, whereas sprinkler installers would be unfamiliar with typical dwelling construction.

Water supplies are a problem. An increasing number of homes are being erected which use wells as a water supply. This will give a minimal supply on a short term basis as water is pumped first to a storage facility rather than directly and immediately to the building.

Freezing presents a serious problem. We must consider not only the normal freezing areas but also the possibility of pipes bursting within heated areas or areas assumed to be heated or insulated.

Overall, however, Home Builder "B" sees no major construction problems.

There is a question as to whether today's sprinklers are property protection oriented or whether it is necessary to develop a life safety oriented type sprinkler.

There is also a question as to whether there is enough knowledge today to warrant the mandating of automatic sprinkler installation. There is a serious question as to whether similar or superior protection could be obtained with mandated detection systems rather than suppression systems. It was further indicated that the government should not be involved in reduction in property damage as this is an insurance consideration. It should confine its efforts to life safety.

With regard to an overall effort to eliminate water meters, it was called to our attention that water meters are installed so that each individual owner pays for the water he uses. This encourages conservation of water which is beoming an important problem in many areas.

1-3.4 INTERVIEW WITH HOME BUILDER "C"

Residential Fire Protection System

The reaction of Home Builder "C" was that because an individual sees fire protection systems installed in commercial property, his reaction should be a feeling of acceptance on the basis of his desire to protect himself from a liability standpoint and to provide some degree of property protection. Under this concept, the existence of a suppression system in a residence could imply inferior construction and potential danger.

To improve fire protection in residential properties, people need to be educated to know their response to fire conditions and to take the necessary measures to keep fire exposure in residential property to a minimum.

Housing Forecast

In the next thirty years, housing will be constructed at the rate of approximately 2 to 2-1/2 million units per year. However, as a result of increasing material, labor and land costs along with government programs in terms of energy conservation, financing and public housing, he is unsure of the exact type of housing that will comprise these units.

Local Regulations

As an indication of the rising restrictions placed by local governments and personal preferences, in November 1971, the lot size was 7200 sq.ft., November 1975 showed this number to increase to 8400 sq. ft. and by November 1976, a median lot size of 9750 sq. ft. is expected.

Costs

Home Builder "C" indicated that ten years ago, land costs were approximately 10% of the purchase price of a home. Today, due to requirements for size and improvements, the lot price is approximately 25% of the purchase price.

If lot size, house size, and interest rates can be effectively reduced, the single family residence can be constructed for $28,000.00 to $30,000.00 per unit. This price may be lower with improvements in technology and construction features.

Buying Patterns

To a certain degree, the American home buyer has little desire to purchase minimal housing. In Denver, a developer changed his pricing to build-in the cost of central air conditioning and subsequently sold 2600 units per year average. A developer in

Dallas decided to build good low cost housing and developed what was termed the "affordable" house. The house was constructed with good workmanship and materials, but the amenities and extras were eliminated. This house was selling for $22,500.00. Although an extensive advertising campaign was initiated, public acceptance of this minimal house was nil. A total of three units were sold under this program. The developer then attempted to make the house more attractive. He added extras such as appliances, garage, air conditioning, etc., and raised the price from $22,500.00 to $28,900.00. The house then sold faster than they could build them.

His experience with subdivision housing in the $34,000.00 price range is that the minimum add-on extra cost is approximately $2,000.00 for amenities. In this area, central air conditioning is the number one extra considered for all housing construction.

I-4. INTERVIEWS WITH DEVELOPERS

I-4.1 Summary

Interviews were conducted with three major residential developers.

Developers indicated that the use of a residential suppression system would be a positive sales factor on most developments where they would occur.

The developer's investments in this construction feature must be returned through trade-offs and other aspects of the development. Regardless of the actual direct cost of installation, a markup would be encountered on the sale of the property to cover the developer's overhead and profit.

It was indicated that construction problems would be very small and design consideration would be important in terms of overall appearance in the structure. The developers indicated the effective acceptance of such a system is in inverse proportion to the actual cost of the dwelling unit in a development. As the price approaches $30,000.00 to $40,000.00, acceptance virtually disappears. It was felt that rather than encourage development through legislative action, incentives should be created to improve the tax situation for the developer in areas with this type of protection.

I-4.2 INTERVIEW WITH DEVELOPER "A" - January 7, 1977

General

Developer "A" discussed low cost residential suppression systems in residential occupancies with their Marketing Department. Appearance is of considerable concern, particularly in a single family unit. This could be solved through the use of sidewall sprinklers or more attractive ceiling sprinklers such as recessed or flush. These, of course, affect cost.

The concern over water damage could affect the sale of single family housing where the suppression system was installed at the discretion of the builder rather than ordered by the owner. There was a feeling expressed that apathy regarding fire is such that there would be little sales appeal.

One and Two Family Dwellings - Owner Occupied

In a single, detached, high value dwelling, an installed fire suppression system would be a definite asset to sales. The degree of acceptability and value from a sales standpoint decreases as the value of the dwelling decreases and disappears at the $30,000 - $40,000 level.

Multi-Family Dwellings

In multi-family housing, the residential suppression system would have more value from a sales standpoint, due to the inherent fear of individuals that adjacent dwelling units will become involved in a fire and create damage or hazard to him.

Trade-offs are of interest particularly with regard to fire wall requirement reduction.

At zero net cost, a suppression system would be a definite marketing asset. At $25 to $50 per room, a suppression system would still improve the marketing capabilities. In excess of $50 per room, it is felt that the advantages would disappear. Cost in excess of zero net per room would be unacceptable in single family dwellings.

Insurance will not affect acceptability except from the standpoint that it will reduce the normal mortgage insurance payments.

I-4.3 INTERVIEW WITH DEVELOPER "B" - December 29, 1976

Developer "B" pointed out that in considering the cost from the developer's standpoint, it is necessary to consider the markup normally applied. This markup involves a multiplier of approximately 1.65 to 1.75. The lower the cost, the higher the multiplier will be.

From an actual installation standpoint, the system would not create any construction problems.

The economic impact of the system is of considerable importance. From a sales standpoint, the system would be sold as an amenity in higher cost buildings.

In lower cost construction, the suppression system would be sold on the basis of reduction in construction costs due to building code trade-offs. These trade-offs would occur primarily in reduction in requirements for plasterboard thickness and in reduction for requirements regarding fire wall separations and attic draft stops.

From the developer's standpoint, additional code savings would result if lot line separations or separations between buildings can be reduced and the density of construction on a particular project site thereby increased.

The primary consideration from a developer's standpoint will be the economic impact. It is important that the net cost on a residential suppression system be brought to zero if the systems are to be acceptable to the developer. At a net cost of zero, the developer is likely to vigorously advertise the fire safety of his particular development with a residential suppression system installed.

It was strongly urged that in lieu of legislating installation, it would be desirable to sell the developer on the advantages of such a system. Tax credits or accelerated tax write-offs would be extremely attractive.

The developer will vigorously resist this type of system if the net cost is not brought to zero.

I-4.4 INTERVIEW WITH DEVELOPER "C"

Developer "C" was involved with a luxury high rise condominium developed in Florida. These condominiums were constructed in a 19 story concrete building, a total of 68 units per building.

The buildings are fully equipped with automatic sprinklers, combination sprinkler and standpipe supply. The budget allowance for the 68 apartments was $100,000 for sprinklers. The actual installation cost cannot be determined because the contractor will not provide this information but Developer "C" is aware that the overall allowance has been exceeded on this contract.

The fact that the apartments were protected by Pamphlet #13 sprinkler system was fully publicized and advertised in the marketing of this building. This Developer's opinion is that the result was that no sales were lost because of the presence of the sprinkler system nor were any sales made strictly because of the sprinkler systems presence in these condominiums.

The sprinklers were required because of a code requirement due to the exit distance of this unit. A substantial effort made on behalf of the developer to eliminate this requirement was unsuccessful and, as a result, the sprinklers were installed.

Developer "C" feels that there is no need for the installation of sprinkler systems of this magnitude in residential properties. He would have preferred the installation of smoke detectors and a fire alarm system in this structure.

The insurance broker for this project indicated that no definite percentage of credit could be designated for the installation of sprinklers since this building, being an ocean front property, faces other insurance problems in placement and underwriting costs.

I-5 INTERVIEW WITH CONTRACTORS AND UNIONS

I-5.1 Summary

Interviews were conducted with contractors and union representatives.

This report is segregated into three components; the sprinkler contractors, piping contractors, and trade unions.

Sprinkler Contractors

The sprinkler contractors indicated the acceptance of this system would be very limited. If municipal requirements were introduced to require the installation, they would avidly market their services to developers in such communities. Systems approaching the 10 to 20 nozzle bracket would be difficult to provide at an installed cost in the vicinity of $50.00 per nozzle, and would probably approach the $80 to $90 per nozzle level.

If a large subdivision could be contracted and the installation provided on a continuing basis, the cost per nozzle would be reduced but it would be difficult to obtain a $50.00 per nozzle installation cost.

The contractors would retain the use of the installation of steel pipe and cast iron components since they are equipped with this material and their personnel are efficient in the installation procedures. They would expand to include copper materials should the scope of their contractural obligations increase to the point where they could afford to acquire an inventory of component parts and adequately train personnel in the proper installation of this material.

The installation of systems in multi-family residences has been encountered on a limited basis where local requirements provide for the installation of sprinkler protection in the common areas of multi-family residential buildings. One contractor has experienced a low cost of $55.00 per sprinkler in a large multi-building apartment complex. This cost reflects the actual piping and sprinkler installation but does not reflect the cost of the water supply connection or control valving equipment, or alarms.

The installation of systems in multi-family properties would be more attuned to their operation.

Contractors normally operate with union personnel. In non-union construction, they would be at a disadvantage trying to obtain competitive pricing for the installation of the systems especially in one and two family residential properties.

Plumbing Contractors

The plumbing contractors indicated their present status is to attempt to avoid the major sprinkler system installations due to union problems they may encounter and the additional cost burdens to properly acquire sprinkler expertise. They indicated that the need for this system would be based on municipal requirements and have mixed feelings as to the actual need for a system.

If they were required to assume the responsibility for the installation of these systems, they would not avoid it so as to maintain their actual work load with the typical staff.

Trade Unions

Interviews with trade unions indicated a present jurisdictional agreement providing for the installation of sprinklers by members of the Sprinkler Fitters Union which is a part of the United Association of Pipe Fitters and includes the plumbers and steam fitters. Local representatives indicated that jurisdictional disputes would be quickly worked out so as to allow for reasonable construction to proceed and no excessive jurisdictional problems to develop.

Under present Union jurisdictional agreements, it would be difficult to contemplate any cost reduction for the installation of a combined cold water domestic and fire suppression system. Such an installation would require the interface of two union personnel and the additional cost involved with such interface.

I-5.2 INTERVIEW WITH SPRINKLER CONTRACTOR "A"

The residential suppression system would be possible if it were mandated by law. General acceptance would probably be nil unless something were to spark interest similar to what has happened with smoke detectors.

If such a law were enacted, he would attempt to sell the system by dealing with developers and home builders but would limit effort for individual sales to existing units.

This work could be handled by a special service crew consisting of trained fitters and approved applicable equipment carried on specialized trucks to reduce installation cost and provide competition for acceptance of his service.

There could be definite trade union problems in the fact that the plumbing contractor would probably want this market since their personnel would be on the job site and would be able to provide a more competitive price than he would having to arrive on each job site independently for his specialized installation.

As far as installation goes, Contractor "A" feels that under current practices he would probably install the system on a steel pipe basis rather than copper since he has limited experience on this but would consider using copper if there were any large jobs that would warrant the acquisition of materials and tools to perform this task.

With regard to cost, he doubts that if a ten sprinkler job were installed that it could be installed for $500 but feels possibly that a $50.00 per sprinkler price could be accomplished ($50/HD) if the job were to be in the neighborhood of 20 sprinklers. Again, it would probably be possible to reduce the cost per installation if a number of installations in a sub-division were contracted at once and could be constructed in a more economical fashion.

I-5.3 INTERVIEW WITH SPRINKLER CONTRACTOR "B"

A residential fire suppression system would be acceptable with insurance benefits and, possibly, in instances where the property owner has deep concern for fire protection. Such systems should be mandated for apartment and tenement buildings especially if non-owner occupied, since these buildings reflect weaker maintenance than do owner occupied structures.

The probable cost of such systems would be in the neighborhood of $125.00 to $150.00 per sprinkler for an individual installation consisting of approximately 10 sprinklers and might reduce to the $80.00 to $90.00 bracket for a twenty sprinkler installation. Contractor "B" would prefer to work with steel materials. If such a system were available, it would probably be a job cut installation using present sprinkler fitters. Their opinion is that the cost of the system will be predicated primarily on the labor cost involved with installation. They presently have under contract a complex wherein they are sprinklering 8 basement apartments in each of 7 buildings. There are a total of 1100 sprinklers on this project and the average cost of installation is approximately $55.00 per sprinkler. This cost does not reflect the cost of the water supply, alarms, or control valve equipment normally necessitated with a typical sprinkler installation.

All piping is exposed.

I-6 INTERVIEW WITH MANUFACTURERS

I-6.1 Summary

Interviews were conducted with three sprinkler manufacturers. Based on the projection of 2 to 2-1/2 million units per year, the market was estimated to be approximately 12 million sprinklers assuming a minimum installation of 6 sprinklers per unit to 35 million sprinklers per year assuming 14 sprinklers per unit to be installed.

The reaction to this volume of business would be to gladly accept the challenge of the additional manufacturing requirements. The capacity of the present sprinkler manufacturing industry would not be severly hampered by the increase in volume. With reference to cost components, two indicated that the standard bronze sprinkler nozzle is presently priced at a minimum if not at a level below actual production costs. The increased usage of these components would either hold the cost at its present level or actually increase costs because of the increased portion of the market that these units would consume. One manufacturer refuted this concept and indicated the increased amount of production would introduce automation that would reduce costs.

Specialty items, i.e., chrome plated, flush, sidewall sprinklers and the major fire protection valving components presently supply the greatest profit margins for their operations. It would appear that these specialty heads would remain at their same cost level or reflect a reduction in cost per unit as the demand for these units grew.

If an outside concern were to develop and introduce automated manufacturing procedures at an increased level over that which presently exists, the overall effect on the present industry and price structures would be significant.

The R & D cost of any improvements to the sprinkler would be quickly absorbed by the large market potential and as such, would not significantly alter the present pricing structure.

The present mechanism for operation of sprinklers has been established as a regulated standard. The development of additional and improved response mechanisms would be a function of the demand for the system and a competitive incentive. No manufacturer indicated present involvement in improvement of the response mechanism to their line of equipment.

Distribution and installation of the products reflect product liability. If a standard were properly developed indicating installation criteria, they would be willing to produce this standard and a kit containing basic components for installation by whomever would be authorized to install the system. More than likely, licensing of contractors would be necessary to insure

reliability of installation.

The continued use of Listed components would assure a certain degree of reliability and protect, not only their interest, but the consumers' interest in providing reliable equipment.

Replacement components would be handled on a limited basis directly through the manufacturer or his "Approved" distributors. This restriction would reduce the incentive for the individual homeowner or property resident to attempt to alter the system. All manufacturers indicated that new products would be dependent upon acceptance and cost. The development of improved sprinklers or alarm equipment would be dependent upon the reaction of the consumer of the product.

I-6.2 INTERVIEW WITH SPRINKLER MANUFACTURER "A" - January 12, 1977

Costs

The present bronze upright or pendent or sidewall sprinkler is priced at approximately $1.36 each, which should be at a level of $2.00. Manufacturers presently sell sprinklers at a loss which is made up for by the profit in various devices including valves, retard chambers, alarm check valves, etc. If larger corporations came into the market with automated manufacturing methods, it is anticipated that the cost of this type sprinkler would remain the same, otherwise the cost of bronze sprinklers might increase to the break even level.

Chrome plated sprinklers, recessed sprinklers and flush or concealed sprinklers are considered "special". With the exception of the chrome plated sprinklers, it is anticipated that a slight decrease in cost per sprinkler would be experienced. The chrome sprinkler would probably stay at the same cost level with a slight decrease possible if automated manufacturing methods were introduced.

The cost of the individual sprinkler is a very minor portion of the cost of the entire system. Assuming fourteen sprinklers per dwelling unit, a decrease in cost of $1.00 per sprinkler would produce only a $14.00 per unit saving.

Market

New type sprinklers could definitely be developed but would be dependent upon selling price acceptability. The ability to automate manufacturing methods is important in maintenance of low price levels. Price considerations would be on the same basis as existing type sprinklers.

It is conceivable that a new actuation method would be developed. The cost would come down quickly to "normal" levels. Research and development costs could be quickly recovered with a market of 12-35,000,000 sprinklers per year. The cost per unit would be dependent upon the cost of the components.

In order to maintain position, it is necessary that products applicable to all lines be offered (industrial, commercial residential, etc.). If sprinklers covering all these lines are not maintained current with competitor's equipment, it would be difficult, if not impossible, to continue to sell equipment in all areas. Development of a new residential standard sprinkler would be strongly considered.

If the Factory Mutual design is made available, it would be a major consideration in the development of a new type residential sprinkler.

Installation

The handyman would not be familiar with requirements of local codes and would lack knowledge with regard to installation standards. Installations by handymen or homeowners would introduce a severe product liability exposure to the manufacturer.

It is likely that with such a market, a new "combination contractor" covering the plumbing trade as well as the mechanical trade, including heating, ventilating, and air conditioning would develop. Such contractors would probably operate on a very localized basis and might well concentrate on residential occupancies or even one and two family dwellings.

Installers of residential suppression systems (and for that matter, all systems) should definitely be licensed or certified. This becomes more important in the residential areas inasmuch as the controls presently exercised by the insurance industry or by local code officials on industrial and commercial installations would probably not be existent in the residential field.

It is doubtful that the industry should license the contractors similar to the fire extinguisher, fire alarm field. Licensing or certification should be handled on a state basis similar to state professional engineering registration or the licensing of sprinkler designers.

Distribution

Inasmuch as sprinkler contractors probably will not be the installers, distribution should not be limited to them.

It is possible that distribution could be through plumbers and expand to the combination contractor or mechanical contractor.

Packages, including pipe, fittings, waterflow devices, for subcontractor installation would be a definite possible distribution method. It is again emphasized that the subcontractor, whether he operates individually and independently or whether he operates through an arrangement with the mass merchandiser, should be licensed or certified.

Sales of individual items should be made only to the licensed or certified subcontractor or a licensed or certified service individual or organization. Parts should not be available on an over-the-counter basis as this would invite homeowner "tinkering" with the system.

Distribution through local hardware or plumbing supply stores should be discouraged inasmuch as the ability to control the actual installer and thereby control the equality of the installation would be difficult.

Sales through catalogs or mail order should be only to certified or licensed installers.

Regardless of the distribution method, it is necessary that the manufacturer know where individual components have been shipped and installed. This is necessary due to the possible need to recall defective units which might be discovered in quality control programs. Products liability is a definite consideration. Considering the fact that this is a whole new field, many lawsuit possibilities exist.

Approval

Components should be listed by a nationally recognized testing laboratory. Quality, operation, and durability are of extreme importance. It was suggested that perhaps even the full system itself should be listed. This system as a whole will only be as good as its weakest link. It is not felt that this requirement for listing will materially affect costs. It would be necessary, however, that a complete new set of testing standards be developed by the testing laboratories related to the ultimate end use of the system.

Inspection and approval of the system is highly desirable and should probably be made by insurance authorities or by municipal authorities. The municipal authorities may not be competent to judge a residential system. The answer to this problem might well be that the licensed installer must certify that his installation meets installation standards. Spot checking would then be necessary tied to the licensing to assure that false certification is not being made.

Maintenance inspections would be highly desirable but it is questionable as to whether these could be obtained. The design life of the system will affect the need for maintenance inspection and their frequencies. The manufacturer will want to protect himself against liability insofar as possible and maintenance inspections must be considered in this context.

I-6.3 INTERVIEW WITH SPRINKLER MANUFACTURER "B"

General

Manufacturer "B" indicated that the potential market for residential suppression systems would be "welcomed with open arms" in the sprinkler manufacturing industry. A demand of 20 million units a year would not create any major problems with manufacturing potential.

The cost of development and approval laboratory listing has been absorbed. Elimination of these requirements would not produce any significant price change in the actual cost of the sprinkler component.

The demand of 20 million units a year would not markedly affect the overall pricing of sprinkler components. Bronze sprinklers are at a no-profit level at present and the other sprinklers would probably remain the same in terms of wholesale costs.

New Product Development

No plans at present and would probably not begin until the need could possibly be shown.

Marketing Practices

A standard must be developed outlining the installation criteria for this type of system. With the standard, they could then market a kit either through wholesalers for the installation by contractors or even as far as mass merchandising through some major retailer. Development of standard criteria would help reduce the product liability problem and allow effective mass merchandising. They have established four regional warehouses in the United States and one in Canada. Any replacement components will be handled on this basis.

All components necessary to system operation should be Listed so as to ensure reliability.

They are not currently working on any rapid response mechanism due to the prohibitive cost nature of the units. The units would probably maintain the same prohibitive feature in overall increase capability of the market.

I-6.4 Interview with Sprinkler Manufacturer "C"

Cost

The present total sprinkler market consists of 5-6,000,000 sprinklers per year. In boom times, the total sprinkler market was 12-15,000,000. If several manufacturers can automate, and this would be possible with this market increase, a small decrease could be expected in the cost of present bronze upright or pendent or sidewall sprinklers.

Chrome upright, pendent, and sidewall sprinklers, recessed sprinklers, and flush or concealed sprinklers would reduce in price.

Market

A potential market for the industry of 12-35,000,000 sprinklers per year would warrant development and manufacture of a new type sprinkler using conventional firing mechanism?

With regard to price, volume is the key and price would be set up on the same basis as presently used.

Product Development

A new sprinkler "firing mode" can be developed. Research and development costs would disappear quickly. Component costs would also be reduced with higher production.

Manufacturer "C" would be very aggressive with regard to the development and marketing of such a new device.

Manufacturer "C" would judge independently the Factory Mutual developments and would follow these developments if they felt there was no better way to design such a residential sprinkler.

Installation

The average handyman or homeowner could install the system. Mechanically, this would not create any problem. It would be essential that the manufacturer supply very complete instructions with the package indicating background information as to the various choices that the handyman has to make.

It is quite likely the sprinklers will be installed by the handyman particularly in existing building construction.

The average plumber could install such a system.

It is unlikely that existing sprinkler contractors would enter this field, however, there is a possibility that the sprinkler contractors would develop a special unit, either within or separate from their company, to concentrate on residential sprinkler installation.

Anyone installing products related to safety within the home should be licensed, including furnace installers, electricians, etc. The same body who licenses the HVAC or plumbing contractor, or the electrical contractor should also license the sprinkler contractor. It would be impossible to enforce homeowner licensing.

Distribution

Sprinklers and/or devices may be distributed through sprinkler contractors only or plumbers, the latter to a rather minor extent.

Distribution through mass merchandisers should be as packages, including pipe, fittings, waterflow devices, etc. for subcontractor or homeowner installation. The latter is not totally desirable. Instructions are of prime importance.

Piecemeal sales of sprinklers, valves, pumps, fittings, pipe hangers, etc., will be necessary. It would not be possible to restrict sales if do-it-yourself projects by the homeowner are possible.

Distribution may be made through local hardware or plumbing supply stores, catalog sales or mail order. Product liability is a problem, but should not be much different than any other product which is available to the consumer.

Approval

All components of the system should be Listed. New testing standards related to the ultimate end use would be necessary.

It is doubtful that either inspection or approval is practical. If licensed contractors, exclusively, were used for installation, a certificate by the contractor would be possible.

Maintenance inspections cannot be done on a mandatory basis and probably could not even be sold on a voluntary basis. The system should be designed to be relatively maintenance free.

I-7 INTERVIEWS WITH MUNICIPAL OFFICIALS

I-7.1 General

Interviews were conducted with officials from County and City jurisdictions.

In most instances, municipal officials were unaware of the existing standard NFPA 13D, "Standard for Installation of Sprinkler Systems For One and Two Family Dwellings and Mobile Homes". A brief review was covered indicating the extent and intent of the information in that standard.

I-7.2 Interview with Water Department Officials

The reaction from the water department personnel (Plumbing Department) indicated a basic acceptance of the use of the domestic tap as a supply to the fire suppression system. The only exception was DeKalb County, Georgia which would require a separate tap for fire suppression supply, due to pressure problems.

Officials indicated that the connection would have to be made on the property side of the domestic meter and that the system would have to be protected against backflow potential. Some would require a double check valve, others would require a simple rubber face check valve.

They would require permits. Plans of all installations would either be submitted to the Building Department or reviewed by the Plumbing Department. It would be expected that a nominal fee would be charged for review of these plans and records maintained by the municipality.

The need for preparation of the plan by an Architect/Engineer would be dependent upon the municipality and the scope of the installation.

Under most municipal codes, it would be required that the system would have to be inspected on a regular basis from the contamination standpoint rather than maintenance standpoint.

I-7.3 Interview with Health Department Officials

Most of the Health Departments contacted were operating as sections of the Building Department.

They were stronger in their requirement for backflow prevention and indicated they would not inspect installed systems.

I-7.4 Interviews with Fire Department and Building Department Personnel

This group of municipal officials represented the broadest range of response.

Building Department officials expressed reluctance for any type of trade-off for system installation. The feeling is that the present housing codes are quite free in terms of design and fire protection regulations. Definite trade-offs would be quite limited.

In multi-family residences, this topic could be considered after official study. The overall zoning approach to lot line separations may be reduced based upon the improved fire protection.

Most building officials indicated limited concern for the need to have plans of the system submitted for approval. This was especially true in one and two family dwellings. The drawing need not be more than a single line sketch. Permits and fees would be more a matter of municipal government decision than their direct opinion.

They were mixed in their opinion for the need for inspection and continuing reinspection. This would be a combination of insurance company responsibility and possible fire department involvement.

Fire Department officials indicated they would consider the system to be an improvement in fire protection. Some officials felt that the installation of early warning fire detectors would probably be readily acceptable and more efficient in terms of life safety.

The use of an automatic alarm connection to the fire department would be a concern for these departments because of false alarm problems and the variety of equipment required.

If large areas were equipped with systems and properly maintained, they could conceivably consider reducing the initial fire department response to a structure equipped with a fire suppression system. It was felt that inspection, permit fees and plan approval was a function of local ordinances and procedures.

The need for maintenance must be effected other than through municipal enforcement. They suggest the consideration for the insurance authority to require and maintain system availability.

SUMMARY

It could be said that most municipal officials would accept the system and would provide moral support for the installation. The need for legislative requirements for the installation is mainly

in multi-family residential property rather than the single family and small apartment buildings. Many officials felt the legislative requirements of individual citizens are more than are presently needed. The basic system definition will greatly affect local ordinances and regulations in the design of the system including the point of connection and also the separation between domestic water and suppression system water. It will be necessary to overcome the desire to meter water and also to isolate the fire protection piping by other than a simple check valve. A presentation outlining meter cost, meter maintenance cost and billing procedure cost as opposed to flat service fee for varying size units might overcome the meter problem. A research study of possible pollution of potable water from the fire suppression system lines would provide a basis for decision as to the type of separation needed between systems.

APPENDIX II

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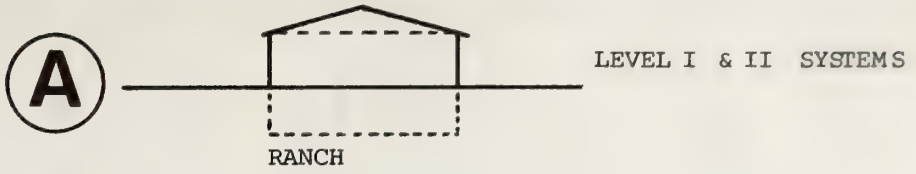
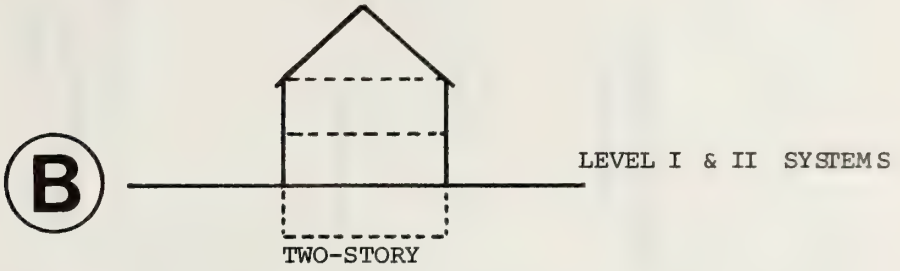
APPENDIX II

DETERMINATION OF SYSTEM COST

Example
Sprinkler System Layouts



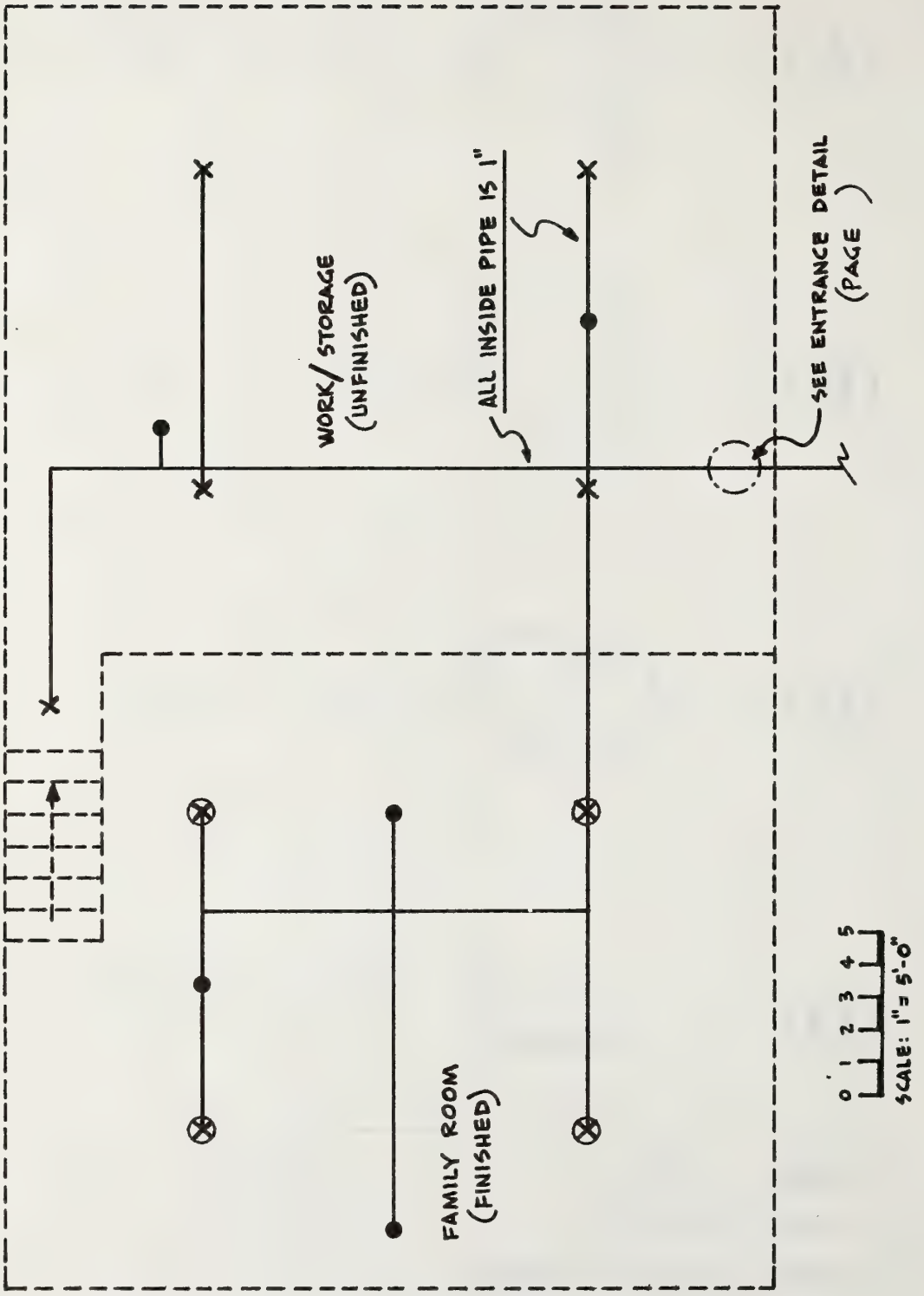


SYMBOL	KEY
—●	----RISER UP
—◀	----SIDE WALL SPRINKLER
—✕	----STANDARD SPRINKLER
—⊗	----RECESSED PENDENT SPRINKLER

Level I System

Basement

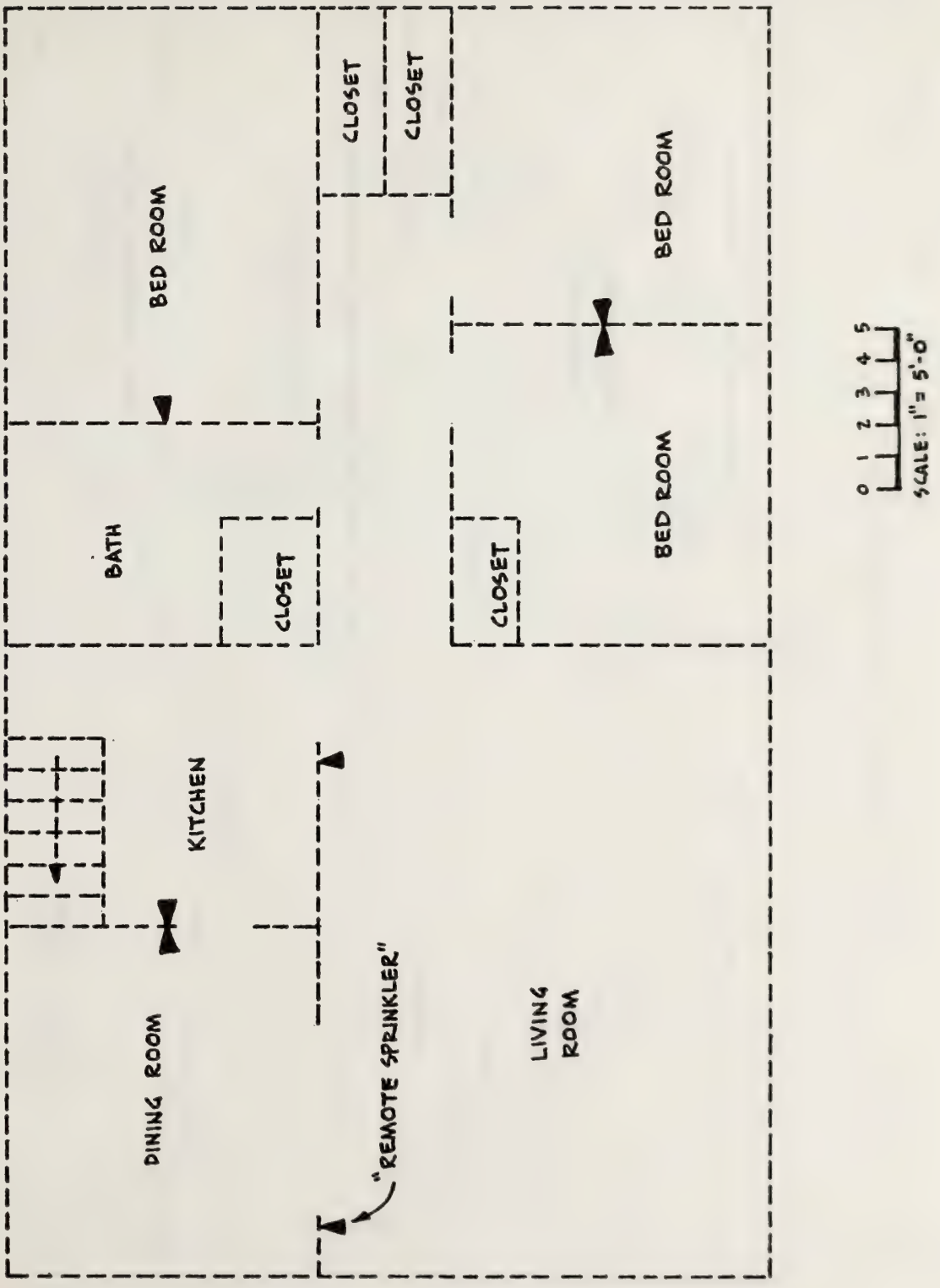
A



Level I System

1st Floor

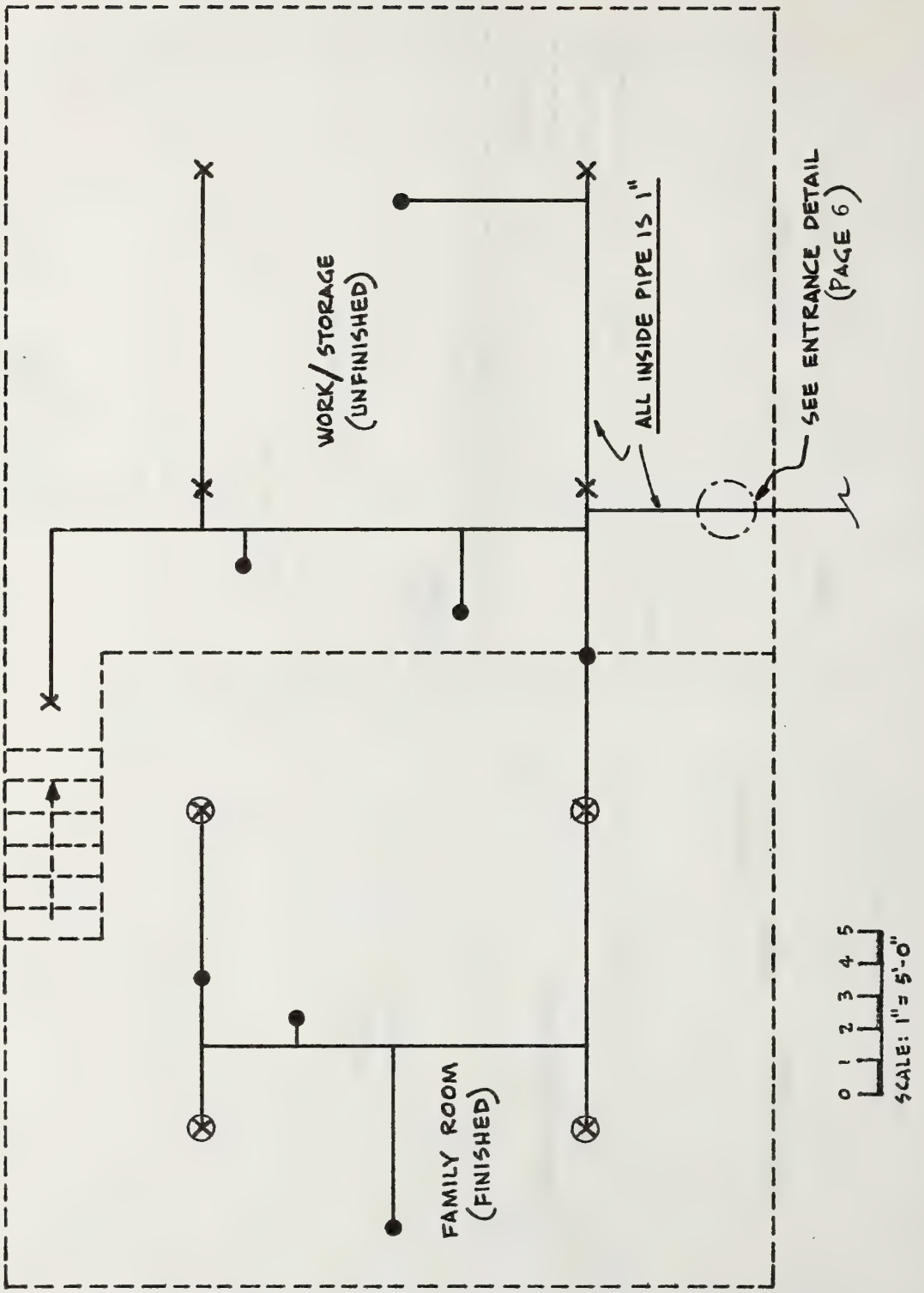
(A)



Level II System

Basement

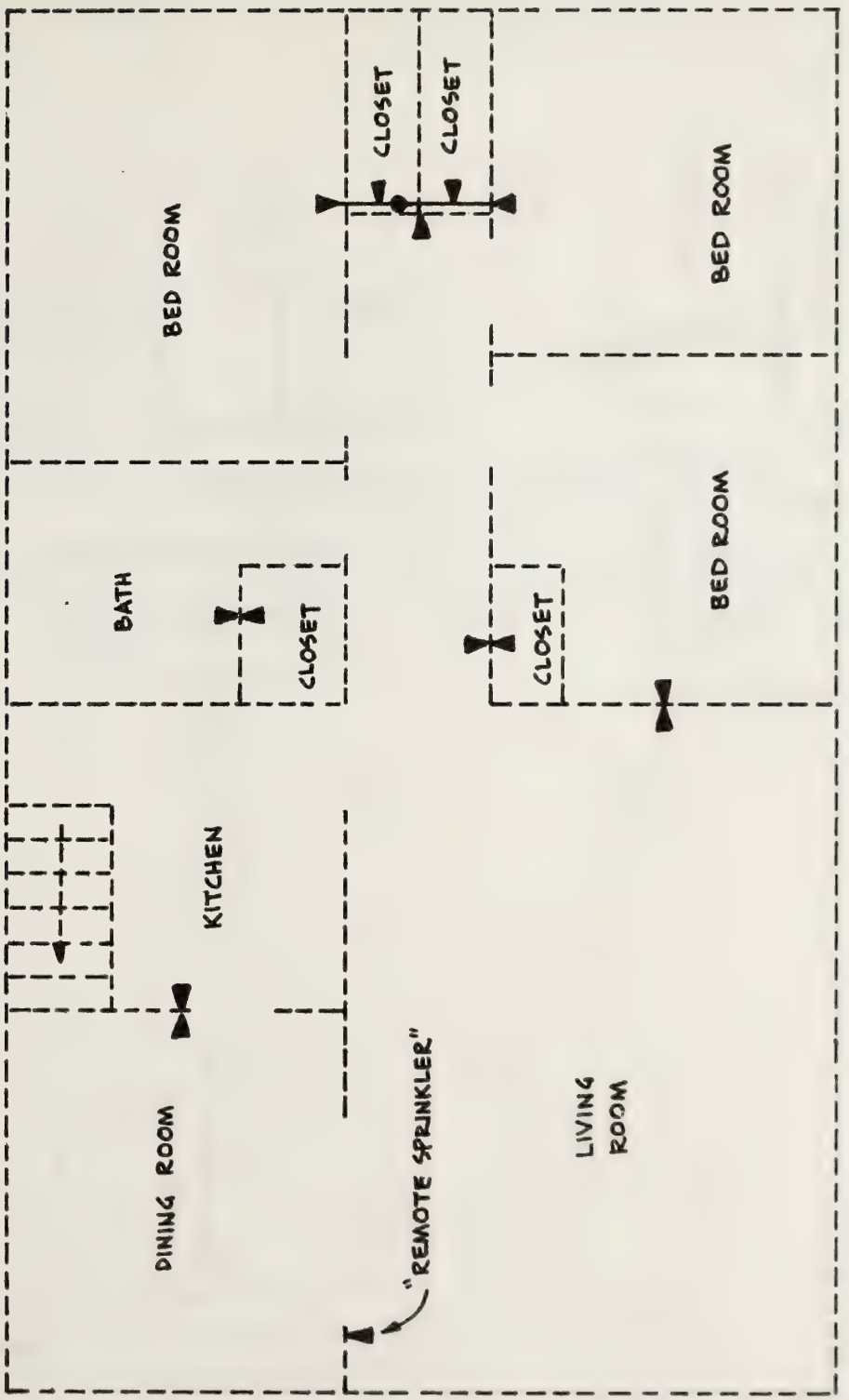
(A)



Level II System

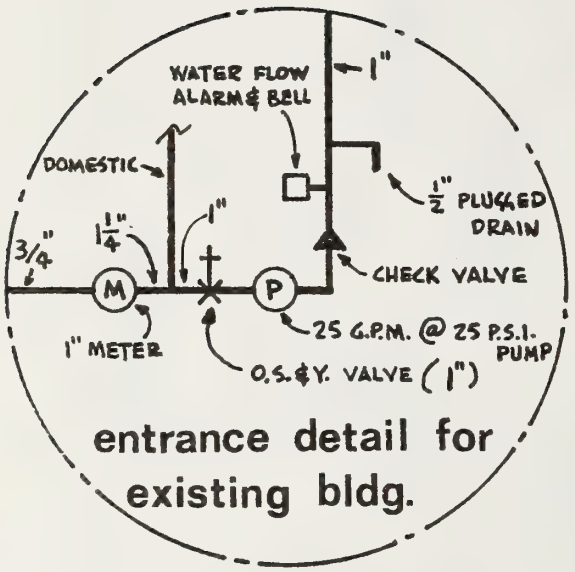
1st Floor

(A)

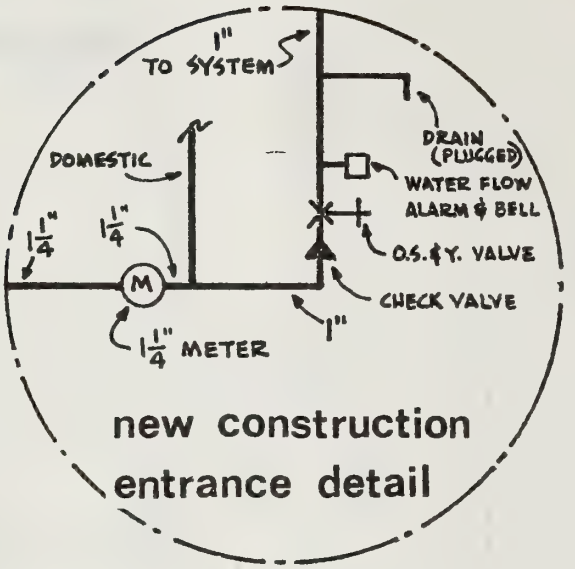


Level I and II Systems

A



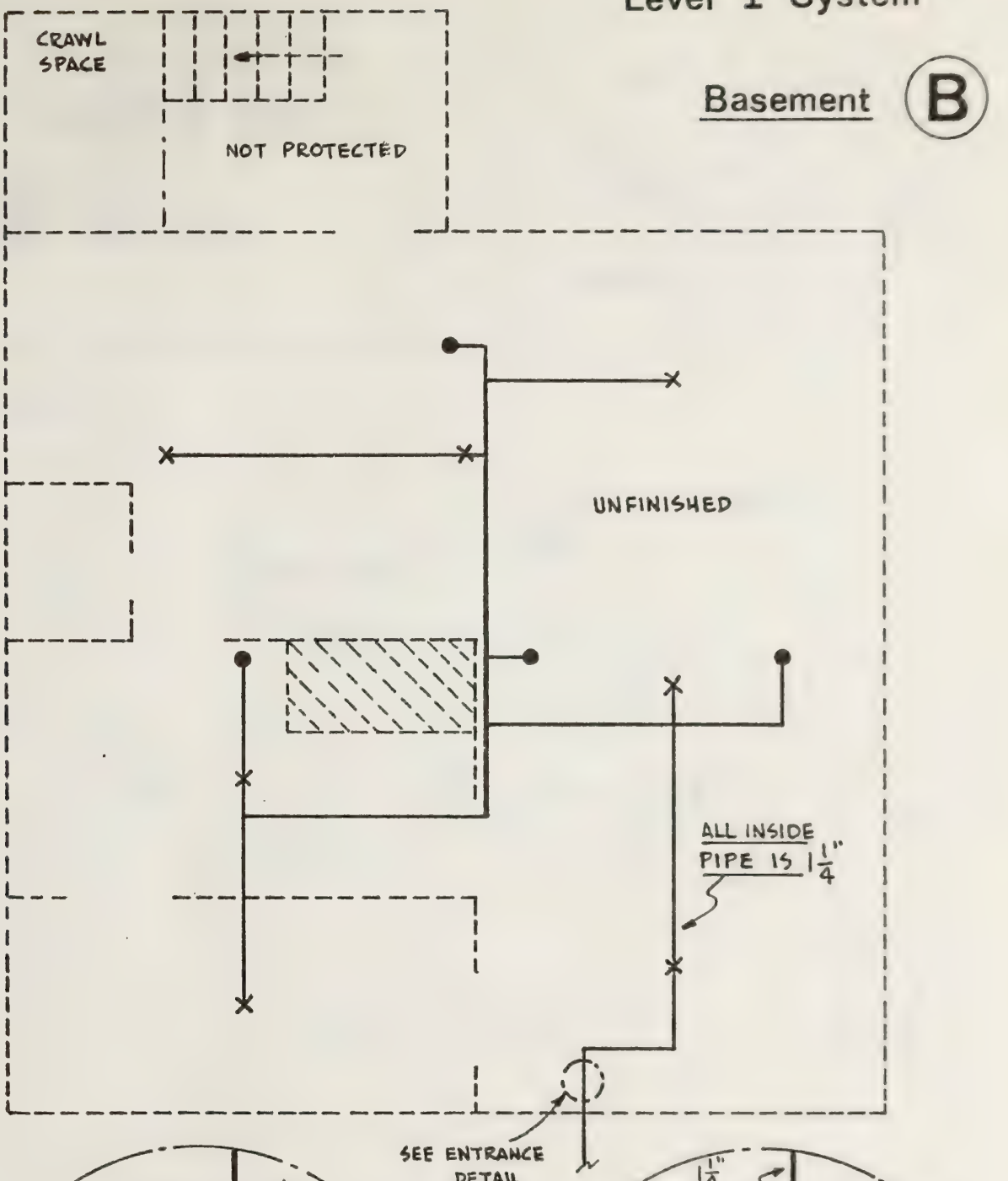
entrance detail for existing bldg.

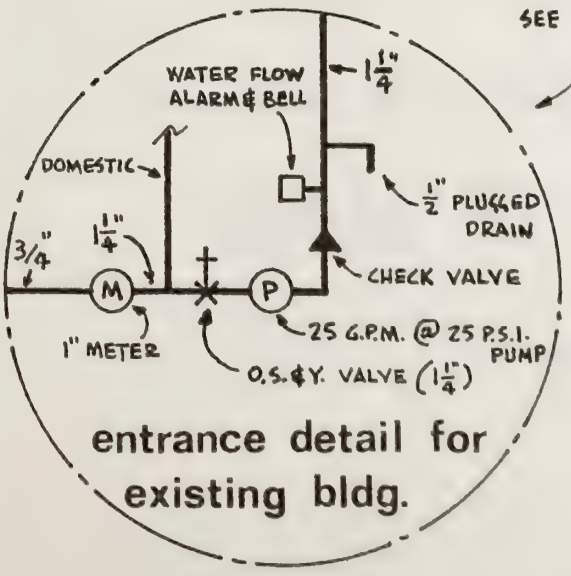


new construction entrance detail

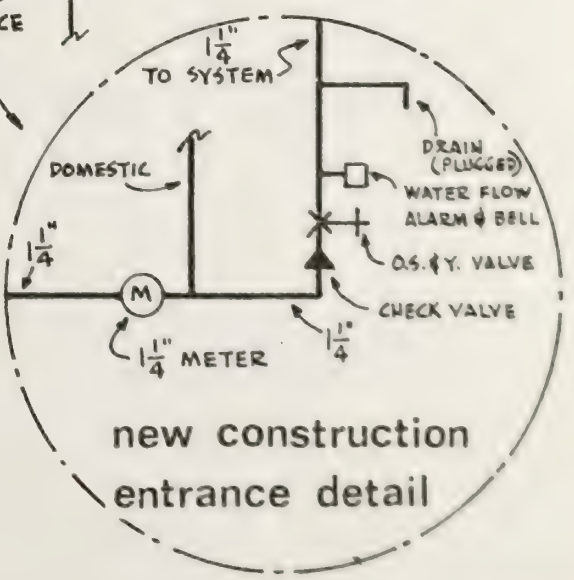
Level I System

Basement (B)





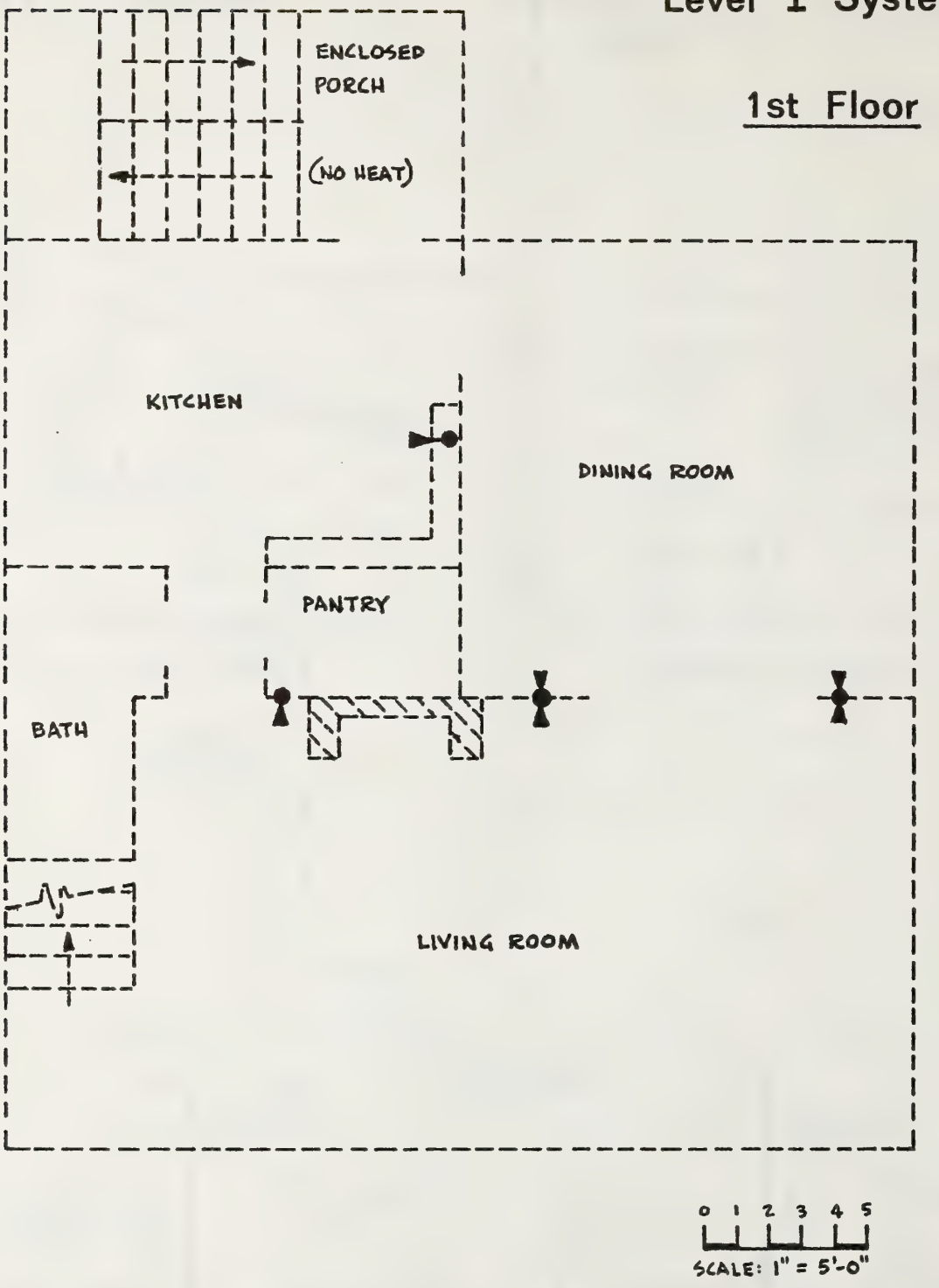
entrance detail for existing bldg.



new construction entrance detail

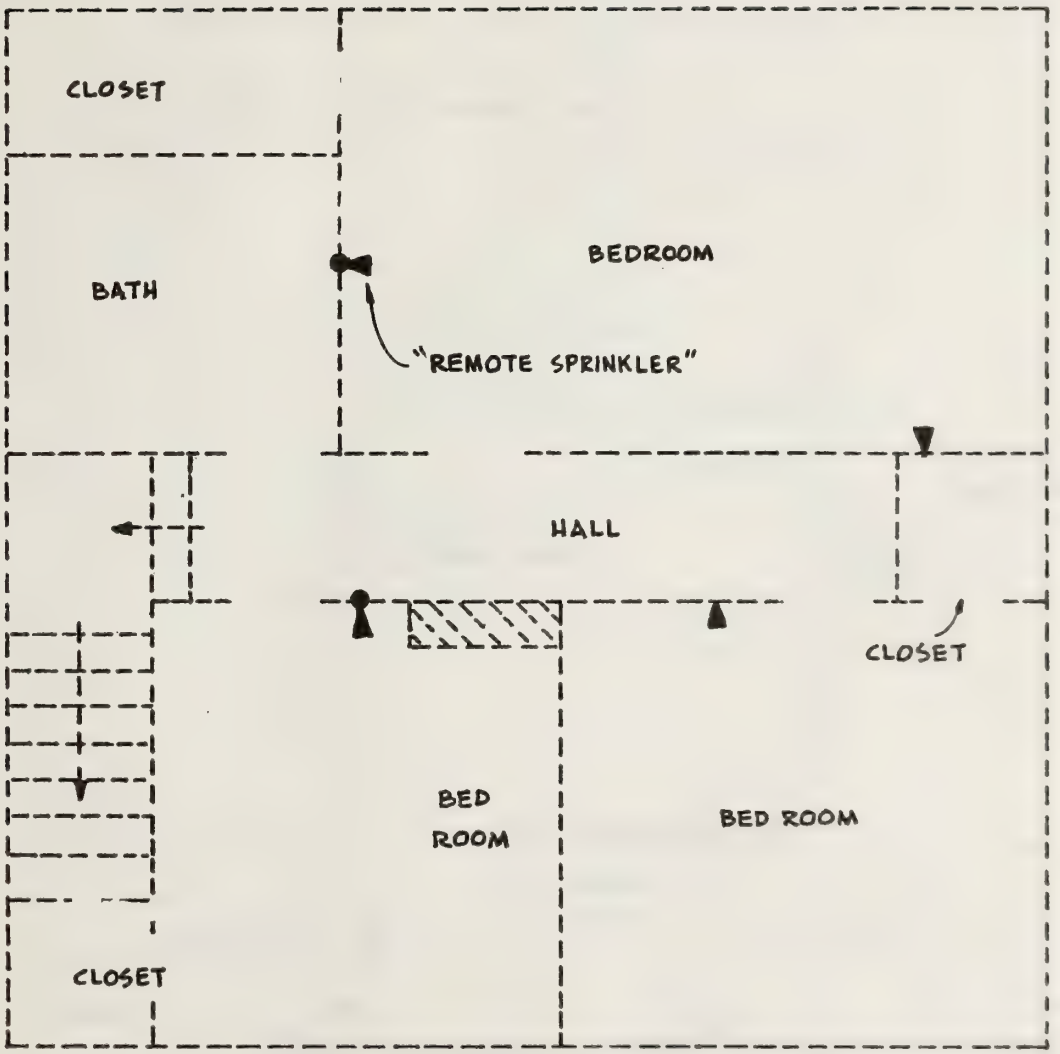
Level I System

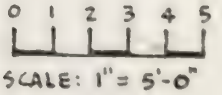
1st Floor (B)



Level I System

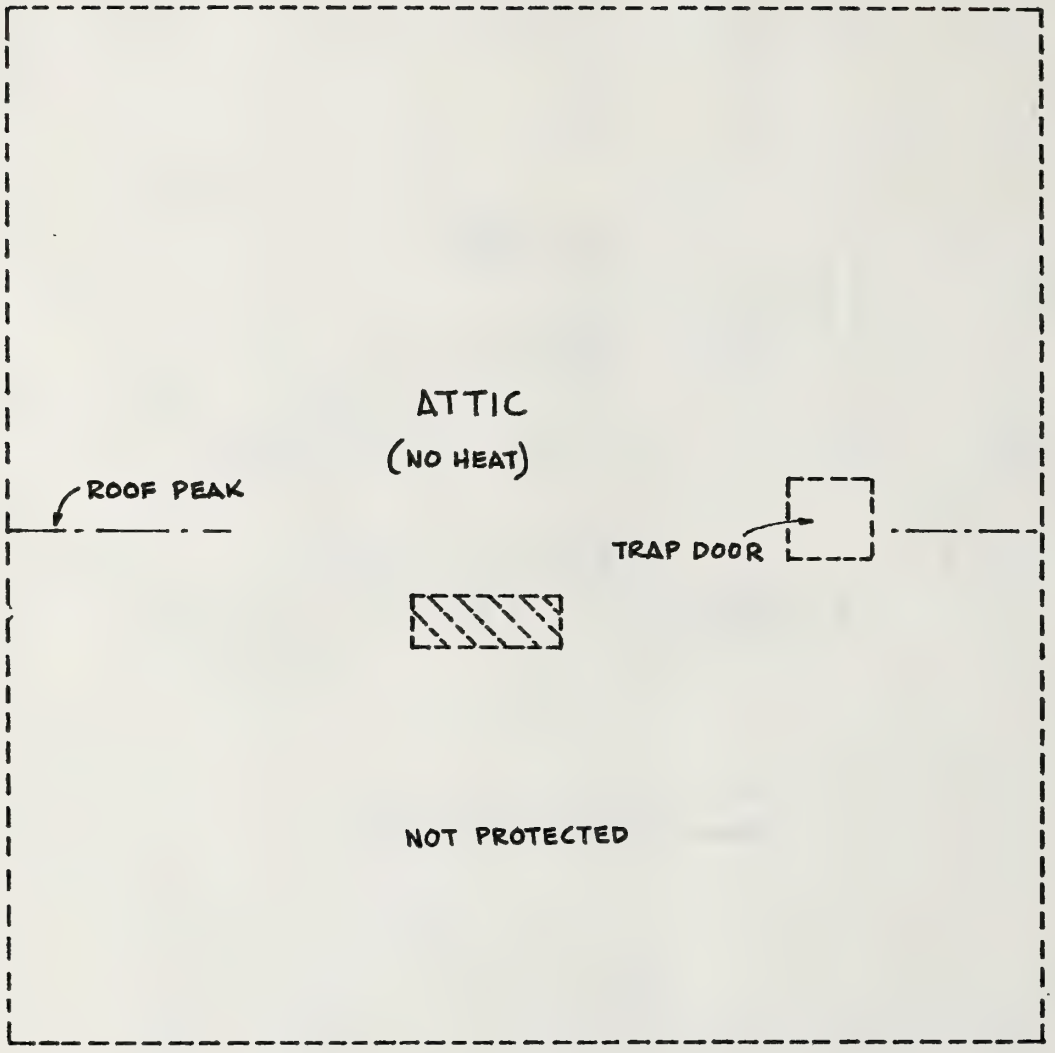
2nd Floor (B)

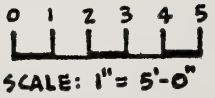




Level I System

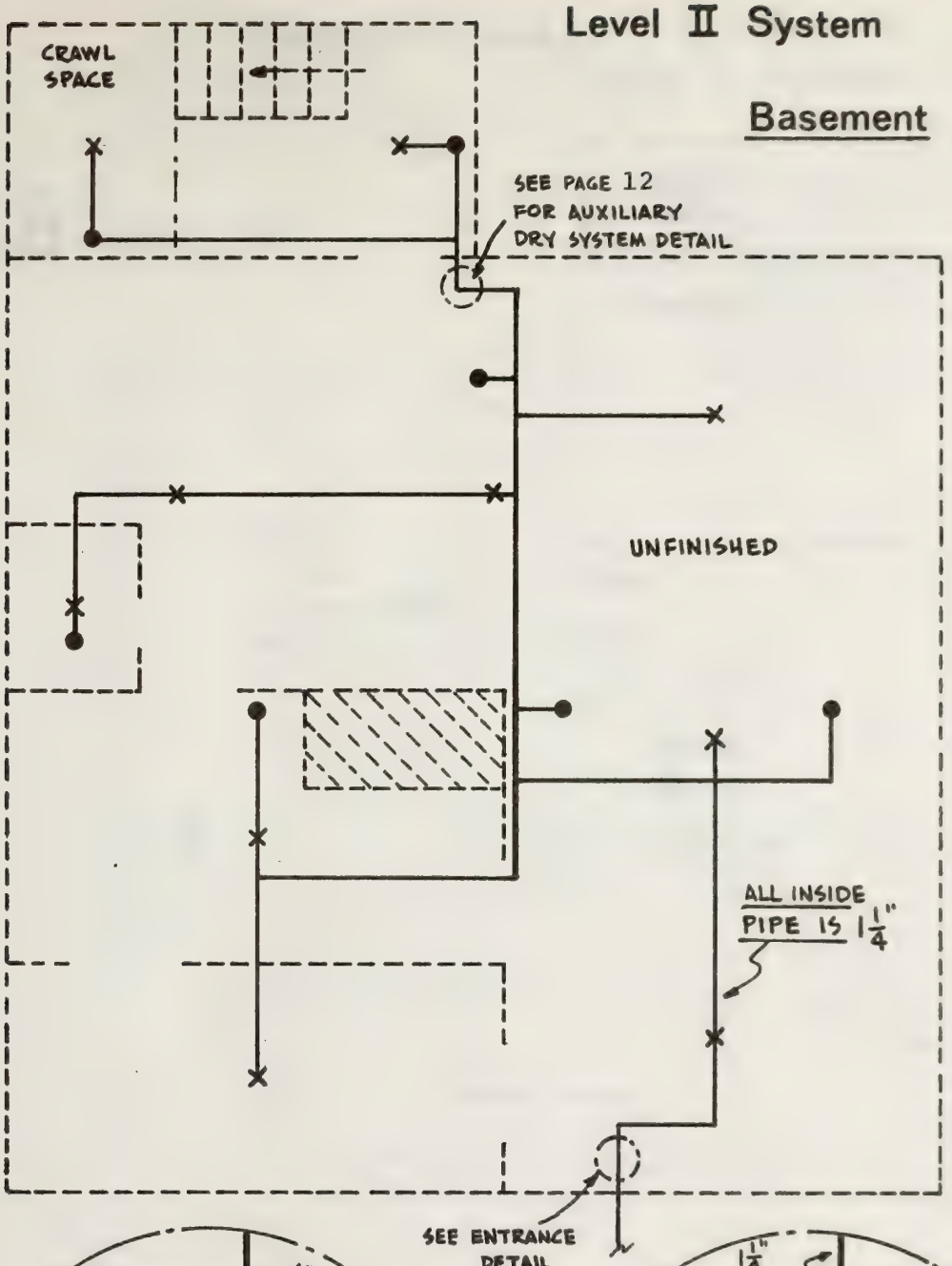
Attic (B)

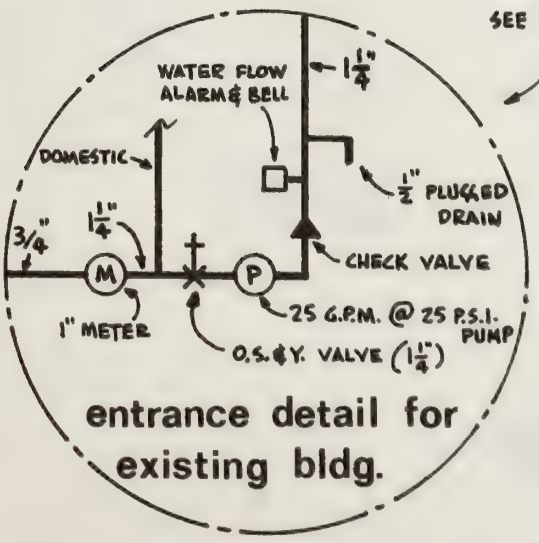




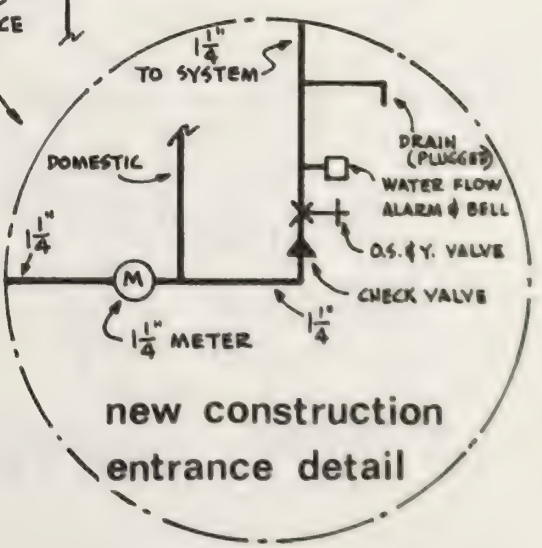
Level II System

Basement (B)



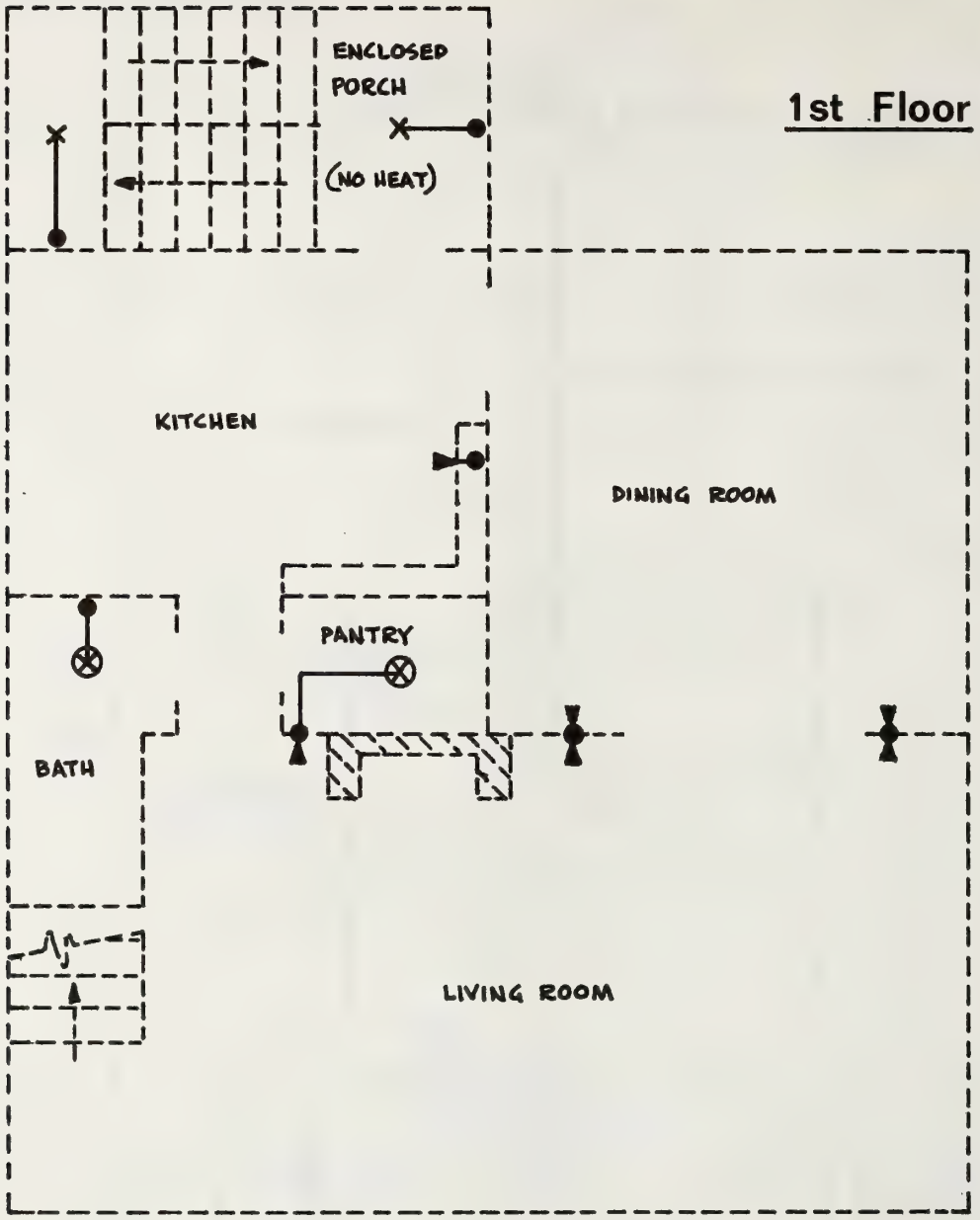


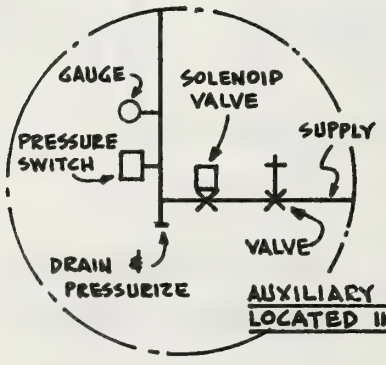
entrance detail for existing bldg.



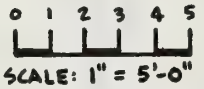
new construction entrance detail

Level II System



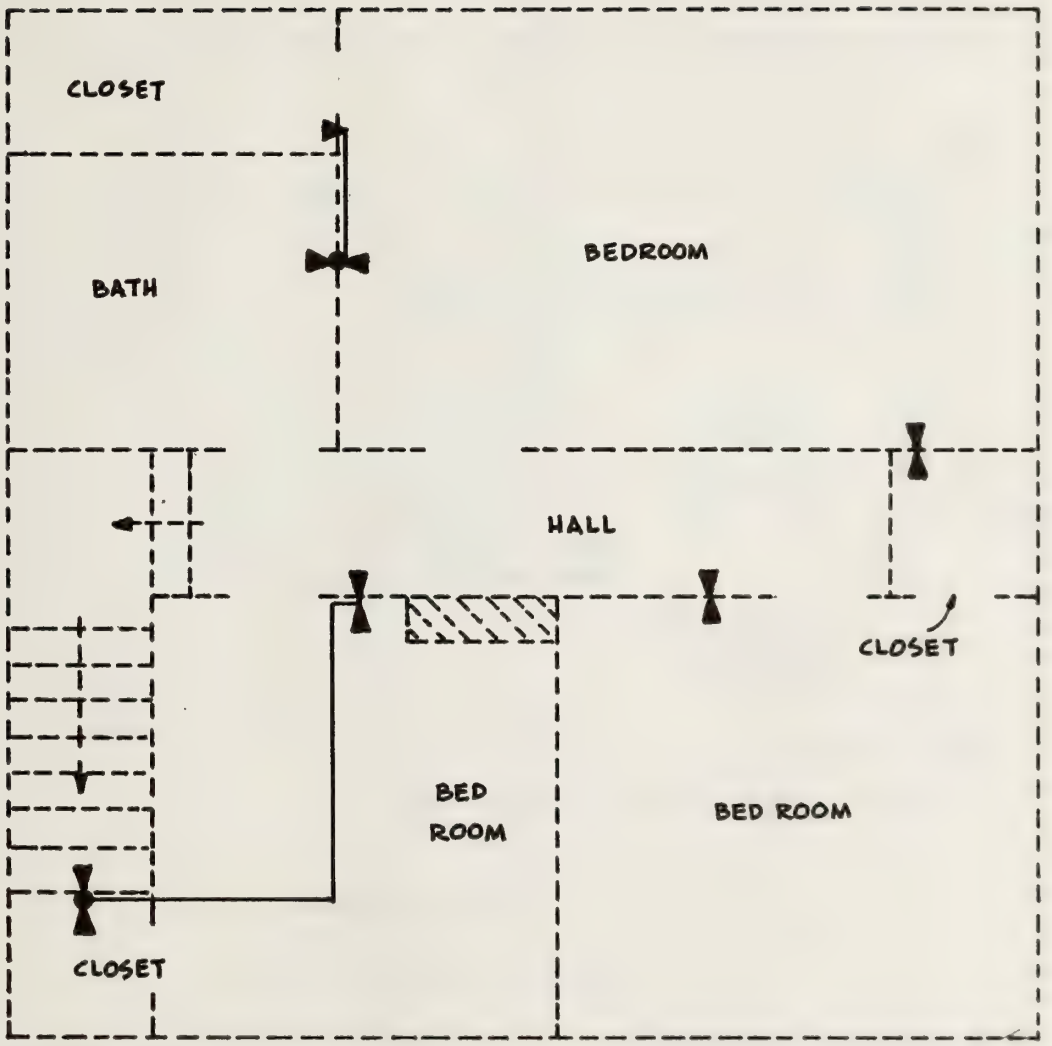


AUXILIARY DRY SYSTEM
LOCATED IN BASEMENT



Level II System

2nd Floor (B)

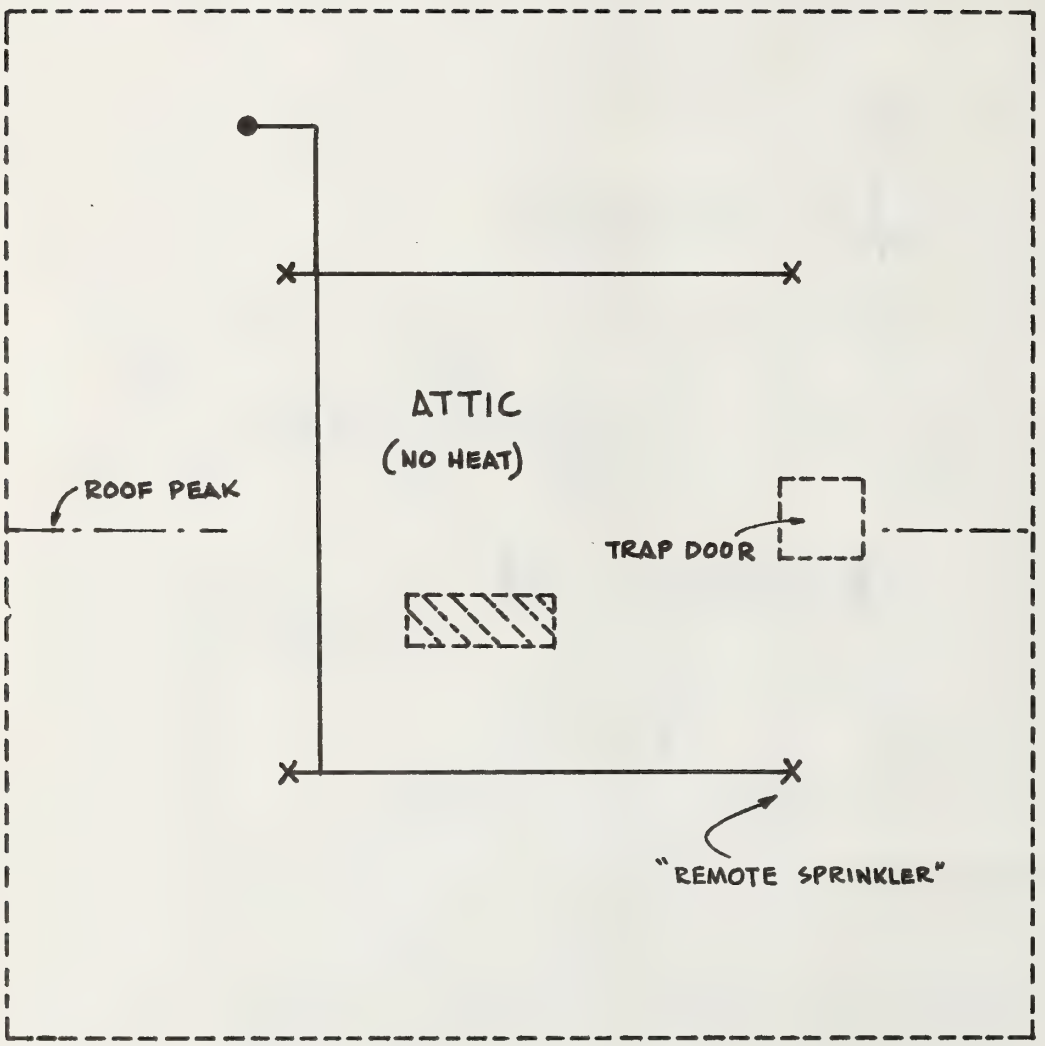


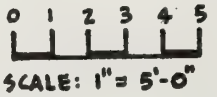
0 1 2 3 4 5

SCALE: 1" = 5'-0"

Level II System

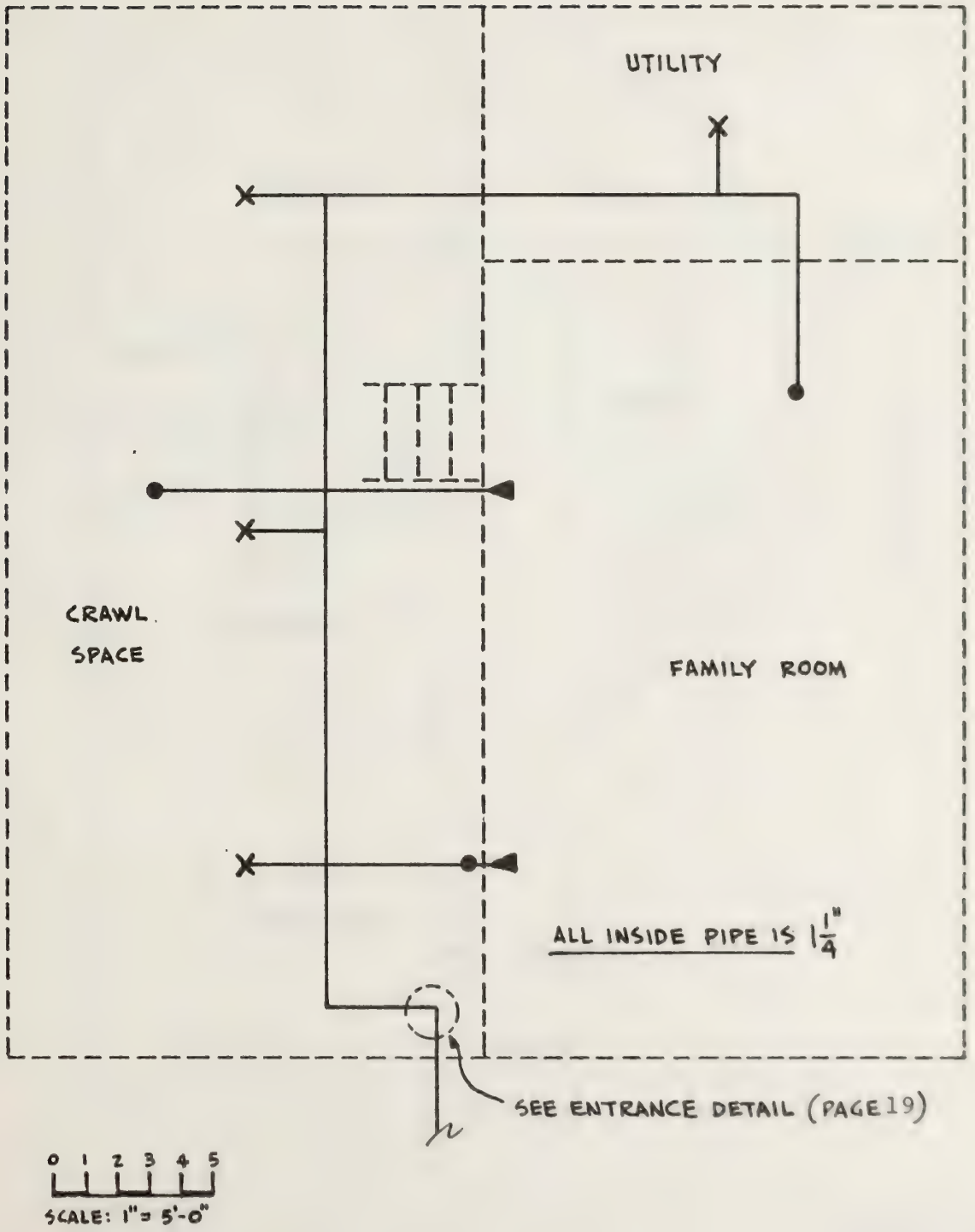
Attic (B)





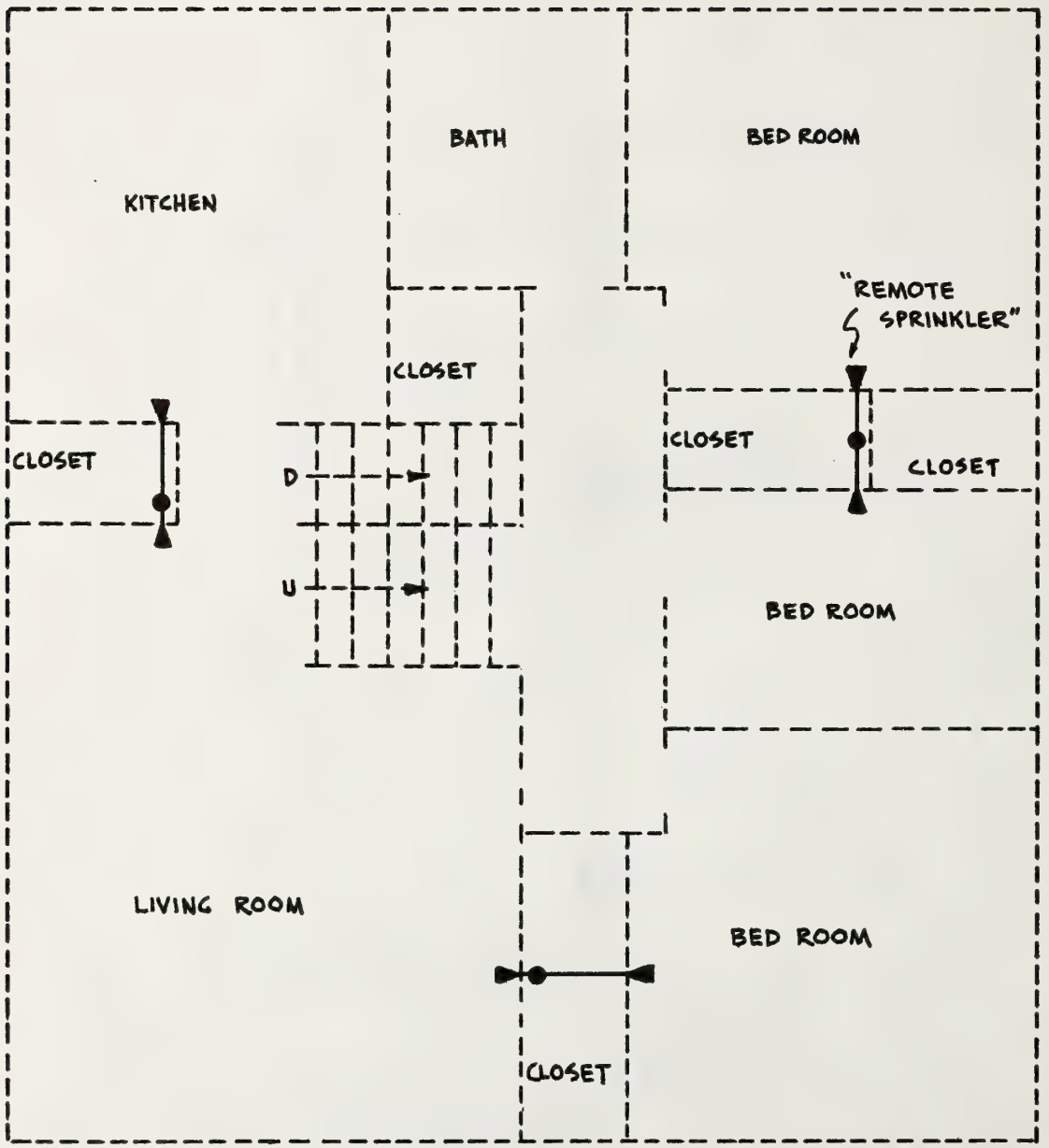
Level I System

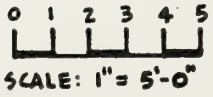
Lower Level



Level I System

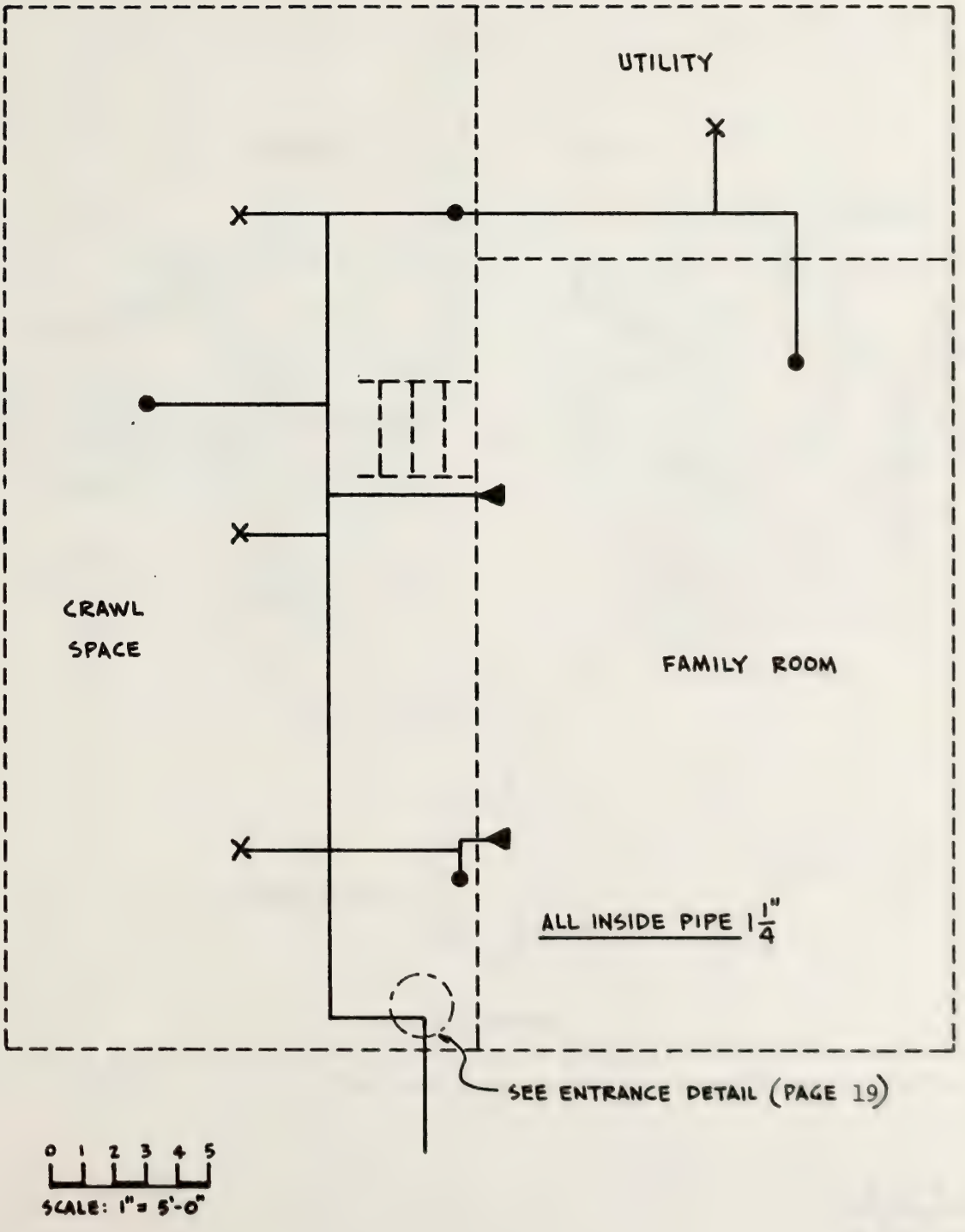
1st & 2nd Level (C)





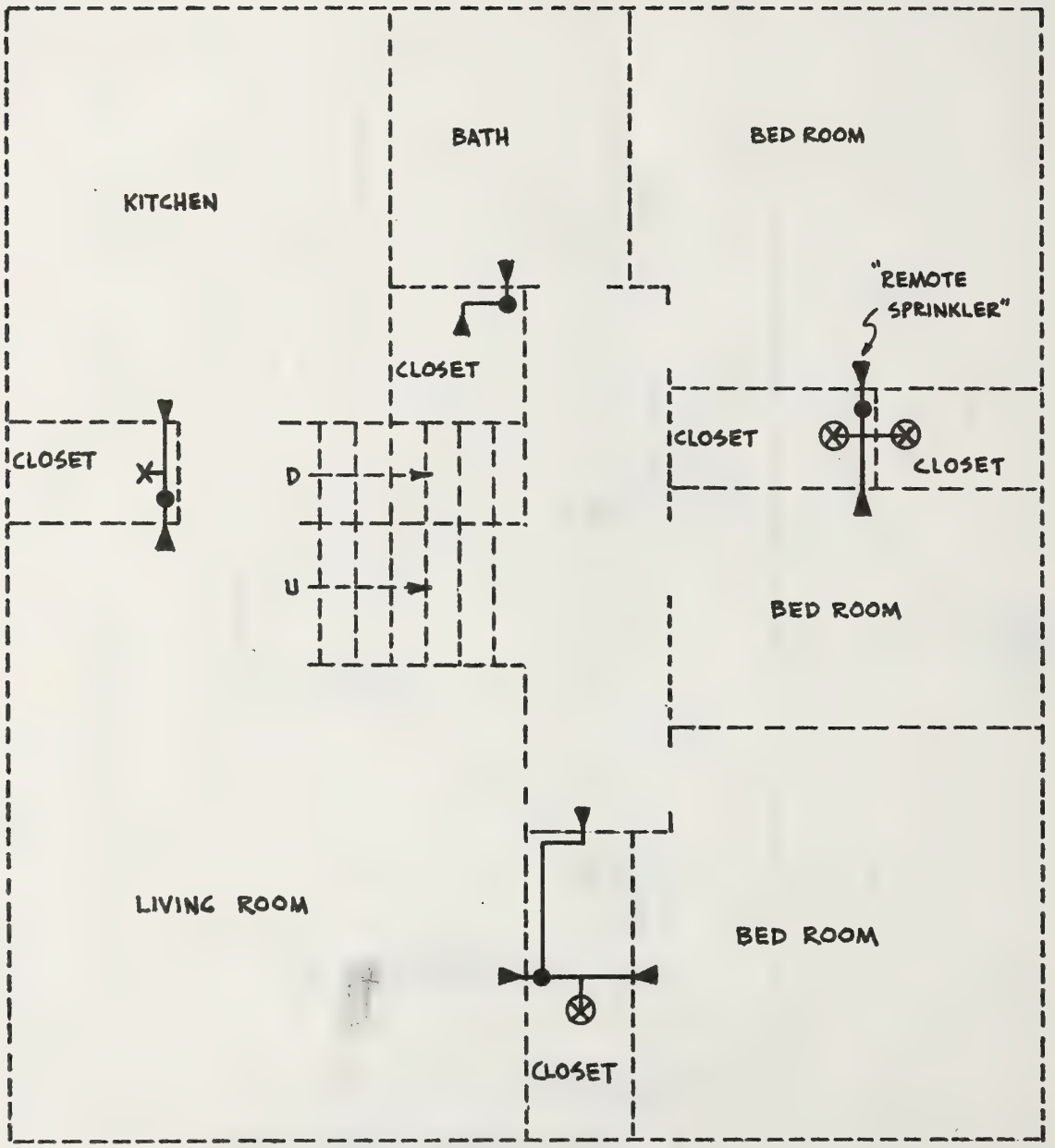
Level II System

Lower Level

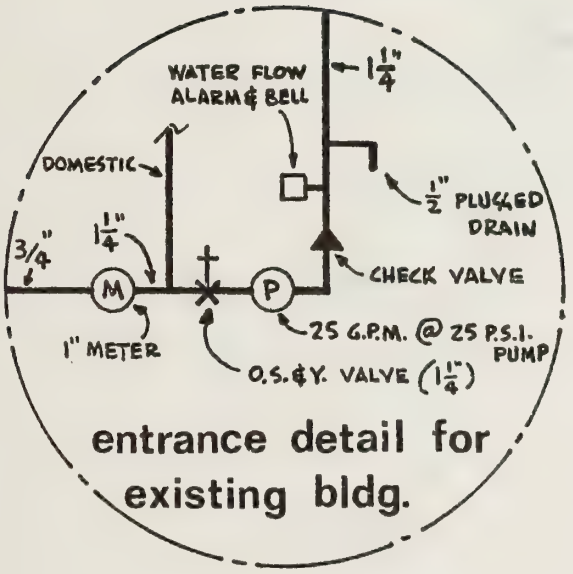


Level II System

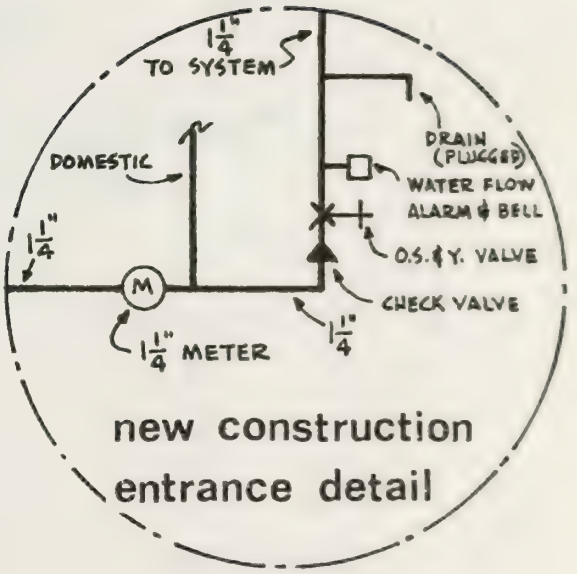
1st & 2nd Level (C)



Level I and II
Systems



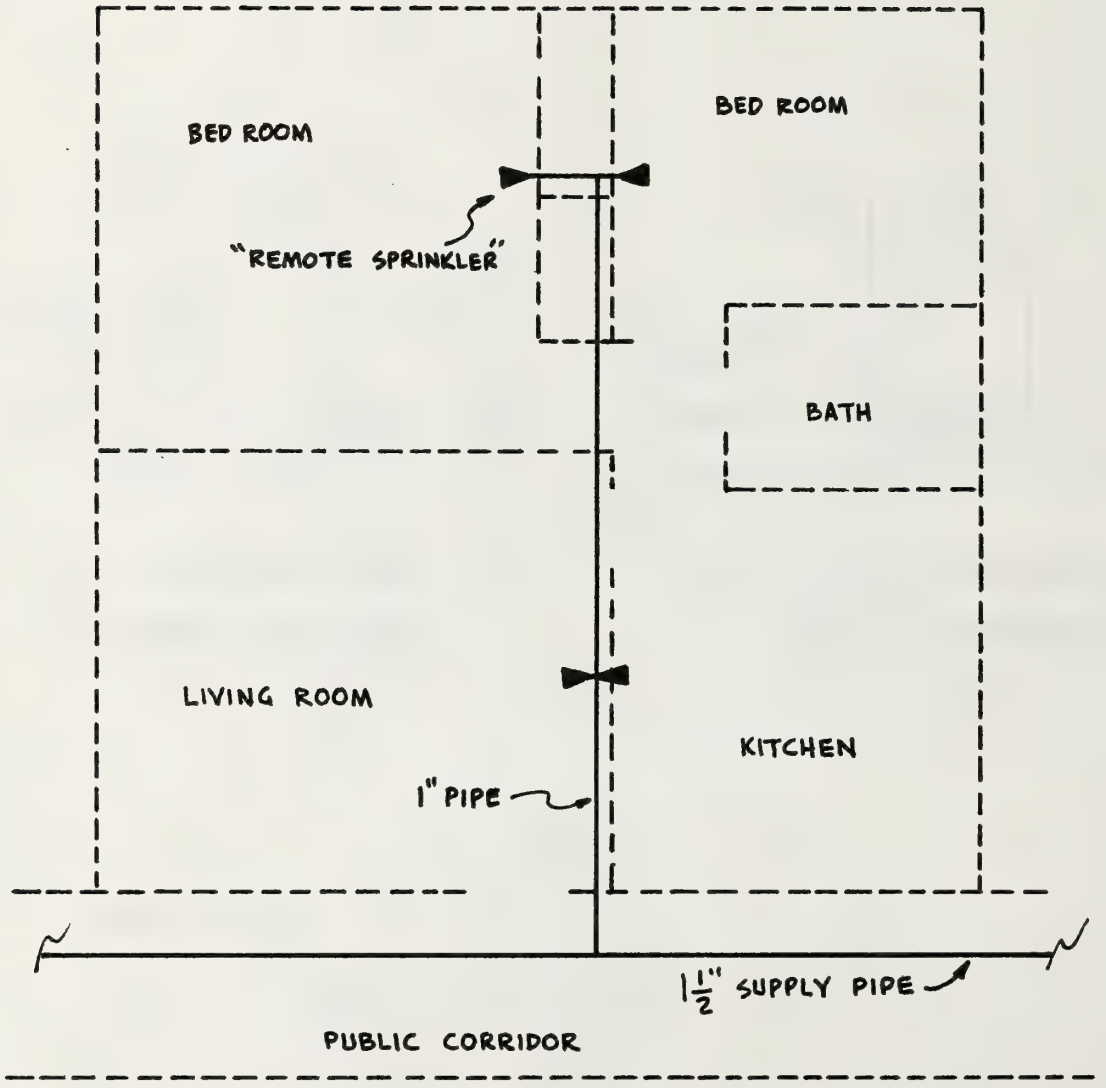
entrance detail for existing bldg.

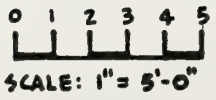


new construction entrance detail

Level I System

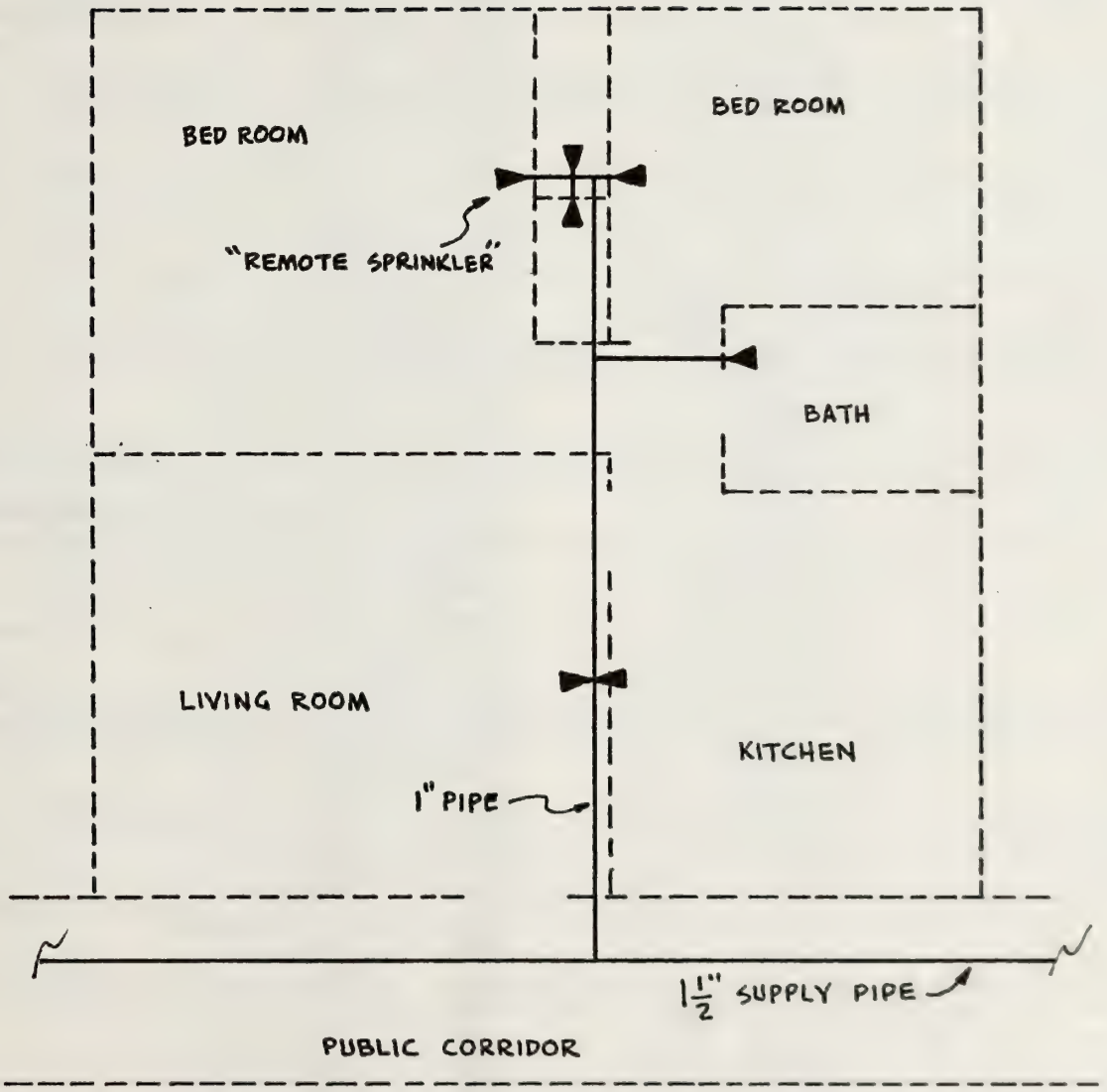
Apartment

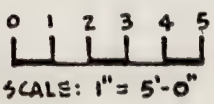




Level II System

Apartment (D)





NAME & LOCATION EXAMPLE "A" - LEVEL I / LEVEL II (NEW / EXISTING)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	$\frac{1}{2}$" HEAD
(NEW)	Q			FTG.		PF	PV	
				TOT.		PE	PN	
REMOTE	Q 25			LGTH. 55		PT 19.5	PT	K = 5.65
HEAD	Q 25	1"	4L, 3T 6V, CKV.	FTG. 28		PF 16.7	PV	
				TOT. 83	.196	PE 5.0	PN	
	Q			LGTH.		PT 41.2	PT	NOTE: REMOTE HEAD IS SAME FOR LEVEL I AS FOR LEVEL II
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
METER	Q			LGTH.		PT 41.2	PT	
	Q 25	$1\frac{1}{4}$"		FTG.		PF 2.0	PV	
				TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 43.2	PT	45.8 < 50
	Q 25	$1\frac{1}{4}$"		FTG.		PF 2.6	PV	
				TOT. 50	.052	PE	PN	
	Q			LGTH.		PT 45.8	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
LEVEL II	Q			LGTH.		PT	PT	
(EXISTING)	Q			FTG.		PF	PV	
				TOT.		PE	PN	
REMOTE	Q 25			LGTH. 55		PT 19.5	PT	
HEAD	Q 25	1"	4L, 3T, GV, CKV.	FTG. 28		PF 16.7	PV	
				TOT. 83	.196	PE 5.0	PN	
	Q			LGTH.		PT 41.2	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
PUMP	Q			LGTH.		PT	PT	PUMP: 25 G.P.M. / 25 P.S.I.
	Q 25			FTG.		PF -25.0	PV	
				TOT.		PE	PN	
METER	Q			LGTH.		PT 16.2	PT	
	Q 25	1"		FTG.		PF 3.6	PV	
				TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT	PT	
	Q 25	$\frac{3}{4}$"		FTG.		PF 31.5	PV	
				TOT. 50	.630	PE	PN	
CONN. TO	Q			LGTH.		PT 51.3	PT	51.3 ≈ 50
CITY MAIN	Q			FTG.		PF	PV	
				TOT.		PE	PN	
	Q			LGTH.		PT	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
	Q			LGTH.		PT	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
	Q			LGTH.		PT	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
	Q			LGTH.		PT	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PN	
	Q			LGTH.		PT	PT	
	Q			FTG.		PF	PV	
				TOT.		PE	PV	

NAME & LOCATION EXAMPLE "B" - LEVEL II / LEVEL I (NEW)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	
				FTG.		PF	PV	$\frac{1}{2}$" HEAD
	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 80		PT 19.5	PT	
HEAD	Q 25	$1\frac{1}{4}$"	7L, 8T, CKV, G.V.	FTG. 69	.052	PF 7.8	PV	K = 5.65
				TOT. 149		PE 13.0	PN	
	Q			LGTH.		PT 40.3	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
METER	Q			LGTH.		PT 40.3	PT	
				FTG.		PF 2.0	PV	
	Q 25	$1\frac{1}{4}$"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 42.3	PT	
				FTG.		PF 2.6	PV	
	Q 25	$1\frac{1}{4}$"		TOT. 50	.052	PE	PN	
CONN. TO	Q			LGTH.		PT 44.9	PT	44.9 < 50
				FTG.		PF	PV	
CITY MAIN	Q 25			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
LEVEL I	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 60		PT 19.5	PT	
HEAD	Q 25	$1\frac{1}{4}$"	6L, 3T GV., CKV.	FTG. 37		PF 5.1	PV	
				TOT. 97	.052	PE 10.0	PN	
	Q			LGTH.		PT 34.6	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
METER	Q			LGTH.		PT 34.6	PT	
				FTG.		PF 2.0	PV	
	Q 25	$1\frac{1}{4}$"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 36.6	PT	
				FTG.		PF 2.6	PV	
	Q 25	$1\frac{1}{4}$"		TOT. 50	.052	PE	PN	
CONN. TO	Q			LGTH.		PT 39.2	PT	39.2 < 50
				FTG.		PF	PV	
CITY MAIN	Q 25	$1\frac{1}{4}$"		TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PV	

NAME & LOCATION EXAMPLE "B" - LEVEL II / LEVEL I (EXISTING)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	
				FTG.		PF	PV	$\frac{1}{2}$" HEAD
PROT.	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 80		PT 19.5	PT	K = 5.65
			7L, 8T,	FTG. 69		PF 7.8	PV	
HEAD	Q 25	$1\frac{1}{4}$"	6V., CKV.	TOT. 149	.052	PE 13.0	PN	
	Q			LGTH.		PT 40.3	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
PUMP	Q			LGTH.		PT -25.0	PT	PUMP
				FTG.		PF	PV	
	Q 25			TOT.		PE	PN	25 GPM / 25 PSI
METER	Q			LGTH.		PT 15,3	PT	
				FTG.		PF 3.6	PV	
	Q 25	1"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 15.0	PT	
				FTG.		PF 31.5	PV	
	Q 25	3/4"		TOT. 50	.630	PE	PN	
CONN. TO	Q			LGTH.		PT 50.4	PT	50.4 ≈ 50
				FTG.		PF	PV	
CITY MAIN	Q 25			TOT.		PE	PN	
LEVEL I	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
PROT.	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 60		PT 19.5	PT	
			6L, 3T,	FTG. 37		PF 5.1	PV	
HEAD	Q 25	$1\frac{1}{4}$"	6V., CKV.	TOT. 97	.052	PE 10.	PN	
	Q			LGTH.		PT 34.6	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
PUMP	Q			LGTH.		PT -25.0	PT	PUMP
				FTG.		PF	PV	
	Q 25			TOT.		PE	PN	25 GPM / 25 PSI
METER	Q			LGTH.		PT 9.6	PT	
				FTG.		PF 3.6	PV	
	Q 25	1"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 13.2	PT	
				FTG.		PF 31.5	PV	
	Q 25	3/4"		TOT. 50	.630	PE	PN	
CONN. TO	Q			LGTH.		PT 44.7	PT	44.7 < 50
				FTG.		PF	PV	
CITY MAIN	Q 25			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PV	

17.1

NAME & LOCATION EXAMPLE "C" - LEVEL II / LEVEL I (NEW/EXISTING)

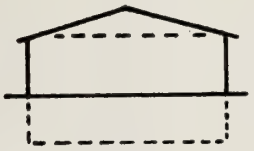
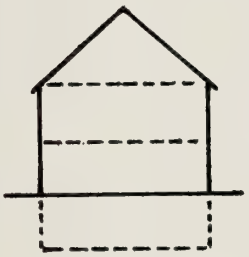
NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	
				FTG.		PF	PV	1/2" HEAD
(NEW)	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 65		PT 19.5	PT	K = 5.65
				FTG. 41		PF 5.5	PV	
HEAD	Q 25	1 1/4"	SL, 4T, GV, CKV.	TOT. 106	.052	PE 7.0	PN	NOTE:
	Q			LGTH.		PT 32.0	PT	REMOTE HEAD IS SAME FOR LEVEL I PROT. AS FOR LEVEL II
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
METER	Q			LGTH.		PT 32.0	PT	PROT.
				FTG.		PF 2.0	PV	
	Q 25	1 1/4"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 34.0	PT	
				FTG.		PF 2.6	PV	
	Q 25	1 1/4"		TOT. 50	.052	PE	PN	
CONN. TO	Q			LGTH.		PT 36.6	PT	36.6 < 50
				FTG.		PF	PV	
CITY MAIN	Q 25			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
LEVEL II	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
(EXISTING)	Q			TOT.		PE	PN	
REMOTE	Q 25			LGTH. 65		PT 19.5	PT	
				FTG. 41		PF 5.5	PV	
HEAD	Q 25	1 1/4"	SL, 4T, GV., CKV.	TOT. 106	.052	PE 7.0	PN	
	Q			LGTH.		PT 32.0	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
PUMP	Q			LGTH.		PT	PT	PUMP
				FTG.		PF -25	PV	
	Q 25			TOT.		PE	PN	25 GPM / 25 PSI
METER	Q			LGTH.		PT 7.0	PT	
				FTG.		PF 3.6	PV	
	Q 25	1"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 10.6	PT	
				FTG.		PF 31.5	PV	
	Q 25	3/4"		TOT. 50	.630	PE	PN	
CONN. TO	Q			LGTH.		PT 42.1	PT	42.1 < 50
				FTG.		PF	PV	
CITY MAIN	Q 25			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PV	

NAME & LOCATION EXAMPLE "D" LEVEL II / LEVEL I (NEW/EXISTING)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV. LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	$\frac{1}{2}$" HEAD
				FTG.		PF	PV	
(NEW)	Q			TOT.		PE	PN	
	Q			LGTH. 25		PT 19.5	PT	
REMOTE	Q 25			FTG. 12		PF 7.3	PV	K=5.65
HEAD	Q 25	1"	L, 2T	TOT. 37	.196	PE —	PN	
	Q			LGTH.		PT 26.8	PT	ASSUME:
				FTG.		PF	PV	3 STORY BUILDING
	Q			TOT.		PE	PN	
	Q			LGTH.		PT 26.8	PT	
SUPPLY				FTG.		PF 3.8	PV	(STANDPIPE NOT
PIPE	Q 25	$1\frac{1}{2}$"		TOT. 150	.025	PE	PN	NEEDED)
	Q			LGTH.		PT 30.6	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	NOTE: REMOTE
	Q			LGTH.		PT 30.6	PT	HEAD SAME FOR
RISER				FTG.		PF .3	PV	NEW/EXISTING
	Q 25	2"		TOT. 35	.007	PE 15.	PN	AND FOR,
	Q			LGTH.		PT 45.9	PT	
BULK				FTG.		PF 1.4	PV	LEVEL II/I
PIPE	Q 25	2"		TOT. 200		PE	PN	
	Q			LGTH.		PT 47.3	PT	
METER	Q 100			FTG.		PF 1.0	PV	ADD 100 GPM
	Q 125	3"		TOT.		PE	PN	DOMESTIC DEMAND
	Q			LGTH.		PT 48.3	PT	
LEAD-IN				FTG.		PF 1.1	PV	
	Q 125	3"		TOT. 50	.021	PE	PN	
	Q			LGTH.		PT 49.4	PT	49.4 < 50
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PV	

mmary

le Family – urban

Reference Letter	Type Of Dwelling	Level Of Protection	xiliary System Cost		Cost Per Head	Sq. Ft. Cost	TOTAL
			or	Mat'l			
A	 RANCH	I		$ -	$ 88.43	$ .71	$ 1,415
		(2000 sq. f		-	147.81	1.18	2,365
				-	43.75	.35	700
		II		-	68.26	.78	1,570
		(2000 sq. f		-	128.26	1.47	2,950
				-	35.00	.40	805
B	 TWO-STORY	I		-	81.47	.58	1,385
		(2400 sq. f		-	139.70	.99	2,375
				-	41.17	.29	700
		II	)	200	80.28	.88	2,810
			)	200	116.43	1.27	4,075
		(3200 sq. f		165	33.00	.36	1,155
C	SPLIT LEVEL	I		-	99.16	.59	1,190
		(2000 sq. f		-	174.58	1.05	2,095
				-	54.58	.33	655
		II		-	71.57	.68	1,360
		(2000 sq. f		-	135.78	1.29	2,580
				-	38.68	.37	735

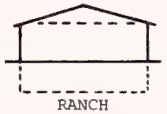
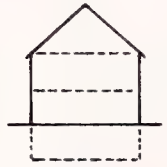
"; Equipment Suppliers and
erhead and Profit.

NAME & LOCATION EXAMPLE "D" LEVEL II / LEVEL I (NEW/EXISTING)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV. LENGTH	FRICTION LOSS P.S.I. / FT.	REQUIRED P.S.I.	NORMAL PRESSURE	NOTES
LEVEL II	Q			LGTH.		PT	PT	$\frac{1}{2}$" HEAD
				FTG.		PF	PV	
(NEW)	Q			TOT.		PE	PN	
REMOTE	Q_{25}			LGTH. 25		PT 19.5	PT	K = 5.65
			L, 2T	FTG. 12		PF 7.3	PV	
HEAD	Q_{25}	1"		TOT. 37	.196	PE —	PN	
	Q			LGTH.		PT 26.8	PT	ASSUME:
				FTG.		PF	PV	3 STORY BUILDING
	Q			TOT.		PE	PN	
SUPPLY	Q			LGTH.		PT 26.8	PT	(STANDPIPE NOT
				FTG.		PF 3.8	PV	
PIPE	Q_{25}	$1\frac{1}{2}$"		TOT. 150	.025	PE	PN	NEEDED)
	Q			LGTH.		PT 30.6	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	NOTE: REMOTE
RISER	Q			LGTH.		PT 30.6	PT	HEAD SAME FOR
				FTG.		PF .3	PV	NEW/EXISTING
	Q_{25}	2"		TOT. 35	.007	PE 15.	PN	AND FOR
BULK	Q			LGTH.		PT 45.9	PT	LEVEL II/I
				FTG.		PF 1.4	PV	
PIPE	Q_{25}	2"		TOT. 200		PE	PN	
METER	Q_{100}			LGTH.		PT 47.3	PT	ADD 100 GPM
				FTG.		PF 1.0	PV	DOMESTIC DEMAND
	Q_{125}	3"		TOT.		PE	PN	
LEAD-IN	Q			LGTH.		PT 48.3	PT	
				FTG.		PF 1.1	PV	
	Q_{125}	3"		TOT. 50	.021	PE	PN	
	Q			LGTH.		PT 49.4	PT	49.4 < 50
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	
	Q			LGTH.		PT	PT	
				FTG.		PF	PV	
	Q			TOT.		PE	PN	

Example: Sprinkler System Cost Summary

Single Family – urban

Reference Letter	Type Of Dwelling	Level Of Protection	Number Of Heads	Construction	Contractor -or- Owner Installed	System Labor Cost	System Mat'l Cost	Access Cost (Existing Const.)	Additional Cost of 1¼" Service Incl. Meter (New Const)	25 G.P.M. 25 P.S.I. Booster Pump Incl. Elect. & Controller	Replace Existing 5/8" Meter With 1" Meter	Auxiliary Dry System Cost		Cost Per Head	Sq. Ft. Cost	TOTAL
												Labor	Mat'l			
A	 RANCH	I	16	NEW	C	$ 900	$ 315	$ -	$ 200	$ -	$ -	$ -	$ -	$ 88.43	$ .71	$ 1,415
		(2000 sq. ft)	16	EXISTING	C	975	290	470	-	470	160	-	-	147.81	1.18	2,365
					O	-	250	90	-	200	160	-	-	43.75	.35	700
		II	23	NEW	C	1,020	350	-	200	-	-	-	-	68.26	.78	1,570
		(2000 sq. ft)	23	EXISTING	C	1,200	350	770	-	470	160	-	-	128.26	1.47	2,950
					O	-	295	150	-	200	160	-	-	35.00	.40	805
B	 TWO-STORY	I	17	NEW	C	875	310	-	200	-	-	-	-	81.47	.58	1,385
		(2400 sq. ft)	17	EXISTING	C	1,010	310	425	-	470	160	-	-	139.70	.99	2,375
					O	-	260	80	-	200	160	-	-	41.17	.29	700
		II	35	NEW	C	1,780	580	-	200	-	-	50	200	80.28	.88	2,810
		(3200 sq. ft)	35	EXISTING	C	1,935	580	680	-	470	160	50	200	116.43	1.27	4,075
					O	-	500	130	-	200	160	-	165	33.00	.36	1,155
C	SPLIT LEVEL	I	12	NEW	C	725	265	-	200	-	-	-	-	99.16	.59	1,190
		(2000 sq. ft)	12	EXISTING	C	850	275	340	-	470	160	-	-	174.58	1.05	2,095
					O	-	230	65	-	200	160	-	-	54.58	.33	655
		II	19	NEW	C	860	300	-	200	-	-	-	-	71.57	.68	1,360
		(2000 sq. ft)	19	EXISTING	C	1,010	300	640	-	470	160	-	-	135.78	1.29	2,580
					O	-	250	125	-	200	160	-	-	38.68	.37	735

Note: Costs Developed Using: "1977 Dodge Manual"; "1977 Building Cost File"; Equipment Suppliers and Local Plumbing/Sprinkler Contractors. - Costs Include Contractors Overhead and Profit.

Summary

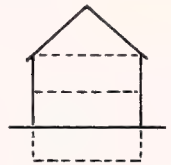
e Family – rural

Reference Letter		Auxiliary Dry System Cost		Cost Per Head	Sq. Ft. Cost	TOTAL
		Labor	Mat'l			
A		$ -	$ -	$117.18	$ .93	$ 1,875
		-	-	149.68	1.20	2,395
		-	-	49.37	.40	790
	-	-	-	88.26	1.02	2,030
		-	-	129.56	1.49	2,980
		-	-	38.91	.45	895
B		-	-	108.52	.77	1,845
		-	-	141.47	1.00	2,405
		-	-	46.47	.33	790
	-	50	200	93.42	1.02	3,270
		50	200	117.28	1.28	4,105
		-	165	35.57	.39	1,245
C		-	-	137.50	.83	1,650
		-	-	177.08	1.06	2,125
		-	-	62.08	.38	745
	-	-	-	95.78	.91	1,820
		-	-	137.36	1.31	2,610
		-	-	43.42	.41	825

: "1977 Building Cost File"; Equipment
:ractors. - Costs Include Contractors

Example: Sprinkler System Cost Summary

Single Family – rural

Reference Letter	Type Of Dwelling	Level Of Protection	Number Of Heads	Construction	Contractor -Or- Owner Installed	System Labor Cost	System Mat'l Cost	Access Cost (Existing Constr.)	25 G.P.M. 50 P.S.I. Booster Pump Includes Elect. & Controller	Auxiliary Dry System Cost		Cost Per Head	Sq. Ft. Cost	TOTAL
										Labor	Mat'l			
A	RANCH	I	16	New	C	$ 900	$ 315	$ -	$ 660	$ -	$ -	$117.18	$ .93	$ 1,875
		(2000 sq.ft)	16	Existing	C	975	290	470	660	-	-	149.68	1.20	2,395
					O	-	250	90	450	-	-	49.37	.40	790
		II	23	New	C	1,020	350	-	660	-	-	88.26	1.02	2,030
		(2000 sq.ft)	23	Existing	C	1,200	350	770	660	-	-	129.56	1.49	2,980
					O	-	295	150	450	-	-	38.91	.45	895
B	 TWO-STORY	I	17	New	C	875	310	-	660	-	-	108.52	.77	1,845
		(2400 sq.ft)	17	Existing	C	1,010	310	425	660	-	-	141.47	1.00	2,405
					O	-	260	80	450	-	-	46.47	.33	790
		II	35	New	C	1,780	580	-	660	50	200	93.42	1.02	3,270
		(3200 sq.ft)	35	Existing	C	1,935	580	680	660	50	200	117.28	1.28	4,105
					O	-	500	130	450	-	165	35.57	.39	1,245
C	SPLIT LEVEL	I	12	New	C	725	265	-	660	-	-	137.50	.83	1,650
		(2000 sq.ft)	12	Existing	C	850	275	340	660	-	-	177.08	1.06	2,125
					O	-	230	65	450	-	-	62.08	.38	745
		II	19	New	C	860	300	-	660	-	-	95.78	.91	1,820
		(2000 sq.ft)	19	Existing	C	1,010	300	640	660	-	-	137.36	1.31	2,610
					O	-	250	125	450	-	-	43.42	.41	825

Note: Costs Developed Using: "1977 Dodge Manual"; "1977 Building Cost File"; Equipment Suppliers and Local Plumbing/Sprinkler Contractors. - Costs Include Contractors Overhead and Profit.

Summary

Multiple Family - urban

Access Cost (Existing Constr.)	Cost Per Head	Sq. Ft. Cost	TOTAL
$ -	$ 65.00	$ .43	$ 260
170	115.00	.77	460
-	45.00	.52	315
300	95.71	1.16	670

"; Equipment Suppliers and
erhead and Profit.

Example: Sprinkler System Cost Summary

Multiple Family – urban

Reference Letter	Type Of Dwelling	Level Of Protection	Number Of Heads	Construction	Contractor -Or- Owner Installed	System Labor Cost	System Mat'l Cost	Access Cost (Existing Constr.)	Cost Per Head	Sq. Ft. Cost	TOTAL
D	APARTMENT	I	4	New	C	$ 165	$ 95	$ -	$ 65.00	$ .43	$ 260
		(600 sq.ft.)	4	Existing	C	195	95	170	115.00	.77	460
		II	7	New	C	210	105	-	45.00	.52	315
		(600 sq.ft.)	7	Existing	C	265	105	300	95.71	1.16	670

Note: Costs Developed Using: "1977 Dodge Manual"; "1977 Building Cost File"; Equipment Suppliers and Local Plumbing/Sprinkler Contractors. - Costs Include Contractors Overhead and Profit.

Other Example Systems Cost Summary

AREA PROTECTED	AGENT	QUANTITY OF AGENT IN SYSTEM	CONSTRUCTION	LABOR COST	MAT'L. COST-VALVE, AGENT CONTAINER, DETECTOR, MTG, NOZZLES, ETC.	ACCESS COST	BOOSTER PUMP 30GPM 50 PSI-2" WATER SVC. 1½" METER	COST PER SQ. FT.	TOTAL COST
EXAMPLE RESIDENCE "C"	CO_2	1600 LBS. (50% CONC.)	NEW	$1,500	$7,500	—	——	$4.50	$9,000
			EXIST	$1,500	$7,500	$1,500	——	$5.25	$10,500
EXAMPLE RESIDENCE "C"	HALON 1301	330 LBS. (5% CONC.)	NEW	$1,500	$8,000	—	——	$4.75	$9,500
			EXIST	$1,500	$8,000	$1,500	——	$5.50	$11,000
EXAMPLE RESIDENCE "C"	DRY CHEMICAL	450 LBS. (.028 LB./ CU. FT. APPL. RATE)	NEW	$2,000	$6,000	—	——	$4.00	$8,000
			EXIST	$2,000	$6,000	$1,500	——	$4.75	$9,500
EXAMPLE RESIDENCE "C"	HIGH EXPANSION FOAM	25 GAL. (CONC.)	NEW	$1,000	$2,000	$400*	$1,800	$2.60	$5,200
			EXIST	$1,800	$2,000	$800*	$2,200	$3.40	$6,800

*INCLUDES DUCT WORK

APPENDIX III

Logic Tree Method of Analysis

III-1 LOGIC TREE METHOD OF ANALYSIS

III-1.1 Discussion

III-1.1.1 The Logic Tree expresses the damage caused by residential fire to both people and property. The factors affecting fire severity and frequency are evaluated by the Tree as to the probability of each factor being able to limit fire development (Damage). Included in the evaluation are items dealing with both the ability and reliability of fire control systems and methods.

III-1.1.2 The elements of the Tree describing the various factors are combined through the mathematical process of "AND" or "OR" gates to arrive at the probability of all factors restricting Damage.

III-1.1.3 The discussion of the Tree and the individual input elements begins with the branches of the Property Damage Tree dealing with automatic suppression system ability and reliability. Considered next are the branches dealing with manual suppression, fuel and construction limited fire and fire frequency. The branches of the Injury Tree which differ from the Property Tree are then discussed.

III-1.1.4 As elements of the Tree are combined to form "higher level" curves, the contributory curves/charts, which were combined to form the new curves, are each identified on the chart.

III-1.2 Accuracy/Precision

While many of the curves appear to be very precise, they can only be as accurate as the input data on which they are based, much of which is subjective. Recognizing the subjective nature of the input data and the fact that the Logic Tree will be a subjective method of analysis until more accurate input data is available, the method of analysis is still a useful tool in that it can be used to approximate:

- The relative effectiveness of various types of automatic suppression systems.
- The probable extent of the reduction in the National Residential Fire Loss caused by the use of automatic suppression systems.
- The impact of automatic suppression systems when used in conjunction with other fire control, suppression and prevention systems.

III-1.3 Damage Conversion

III-1.3.1 Use of the Tree and the associated curves to achieve a measure of the National Residential Fire Loss requires that the input statistics be converted to a cost basis at some level in the Tree.

III-1.3.2 In this study, this was done at the final steps, "National Fire Loss - 1.0" and "National Injury Loss - 1.01". A more extensive study is needed to determine the lowest level of the Tree at which this conversion should occur to be fully valid. It is recognized that it may be as far down in the Tree as the "Fire Damage Limit - 5.10", "Suppression System Damage Limit (Side Effects) - 5.80, 5.60". The full development of these indexing factors was felt to be beyond the scope of this study because an adequate measure of the relative impact of the suppression systems on the National Residential Fire Loss could be achieved without them.

III-1.4 Property Loss - Residential Fires

Figure III-1.4 shows the Property Loss Logic Tree.

III-1.5 Injury - Residential Fires

Figure III-1.5 shows the Injury Loss Logic Tree.

FIGURE III - 1.4

⊙ AND

⊕ OR

PROPERTY LOSS RESIDENTIAL FIRES

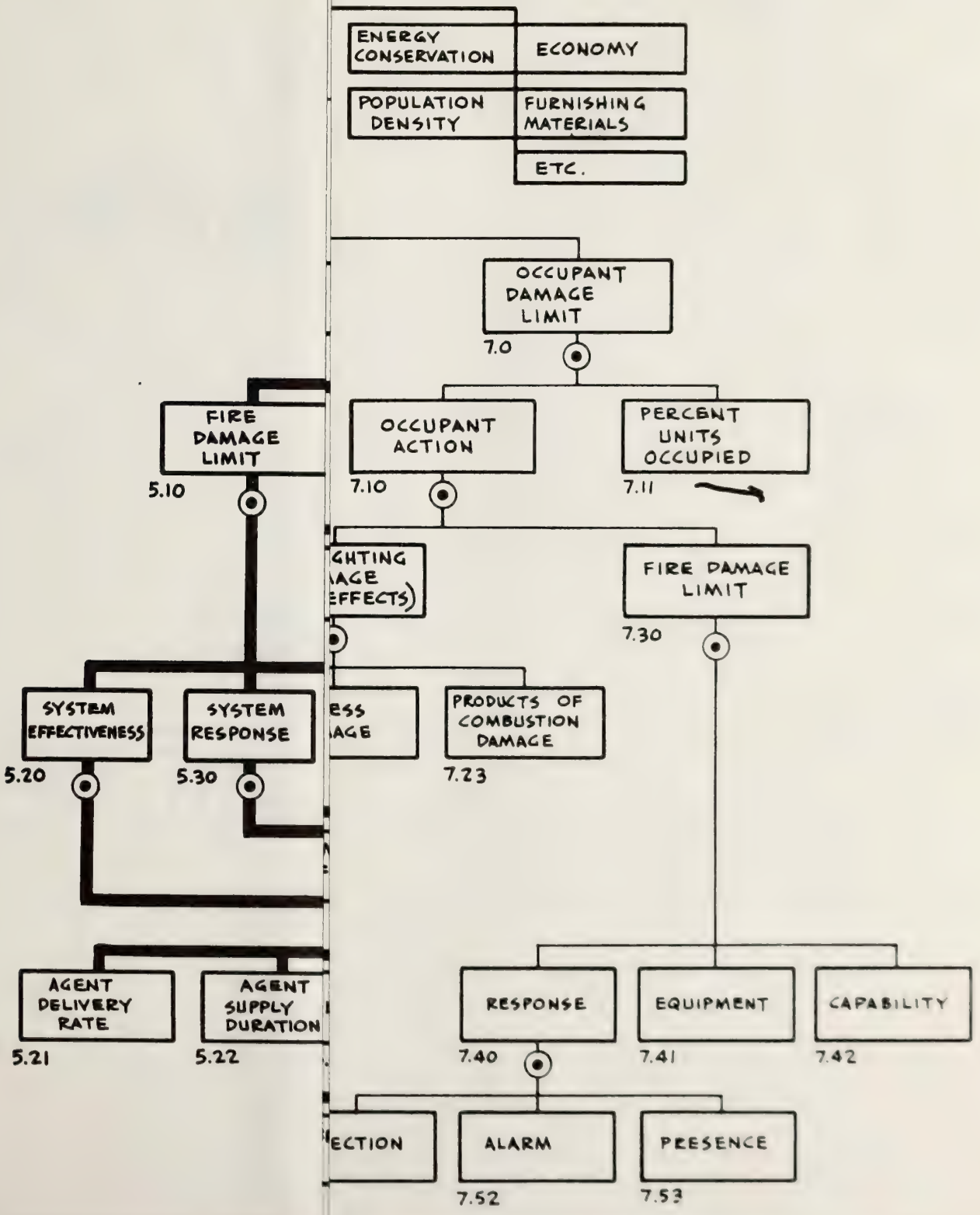
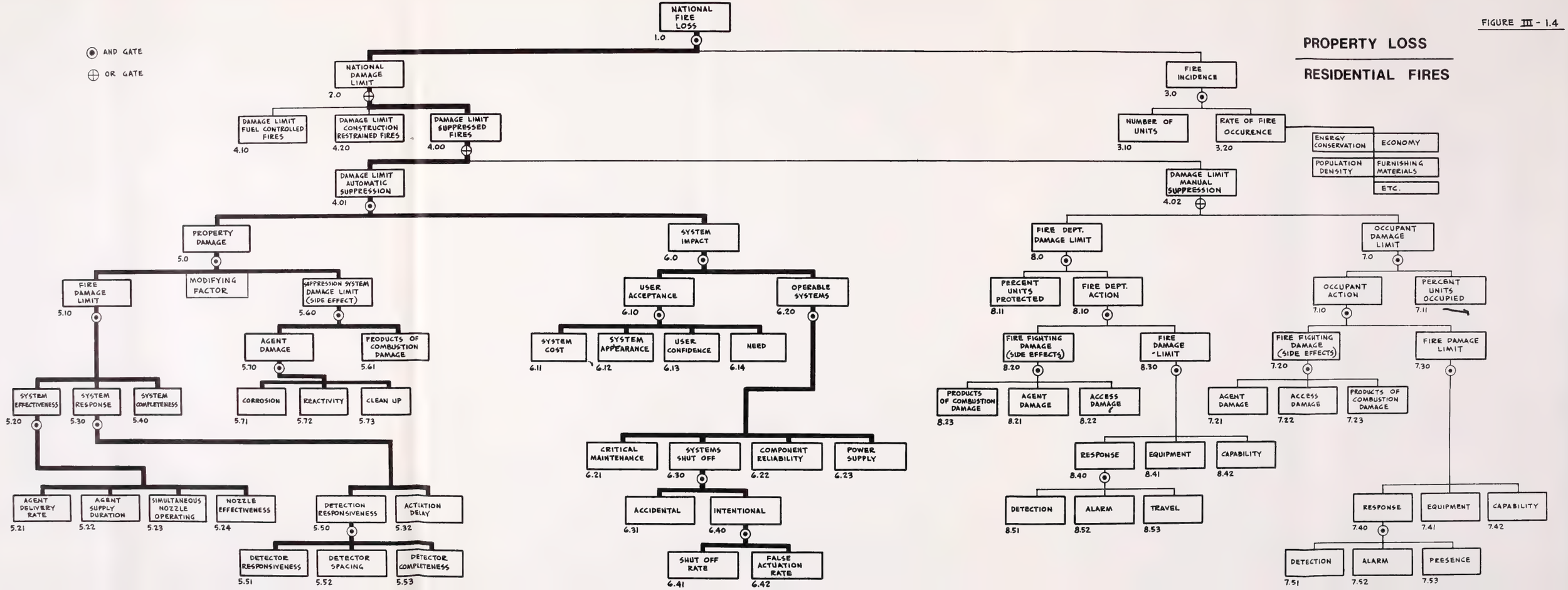


FIGURE III - 1.4

PROPERTY LOSS

RESIDENTIAL FIRES



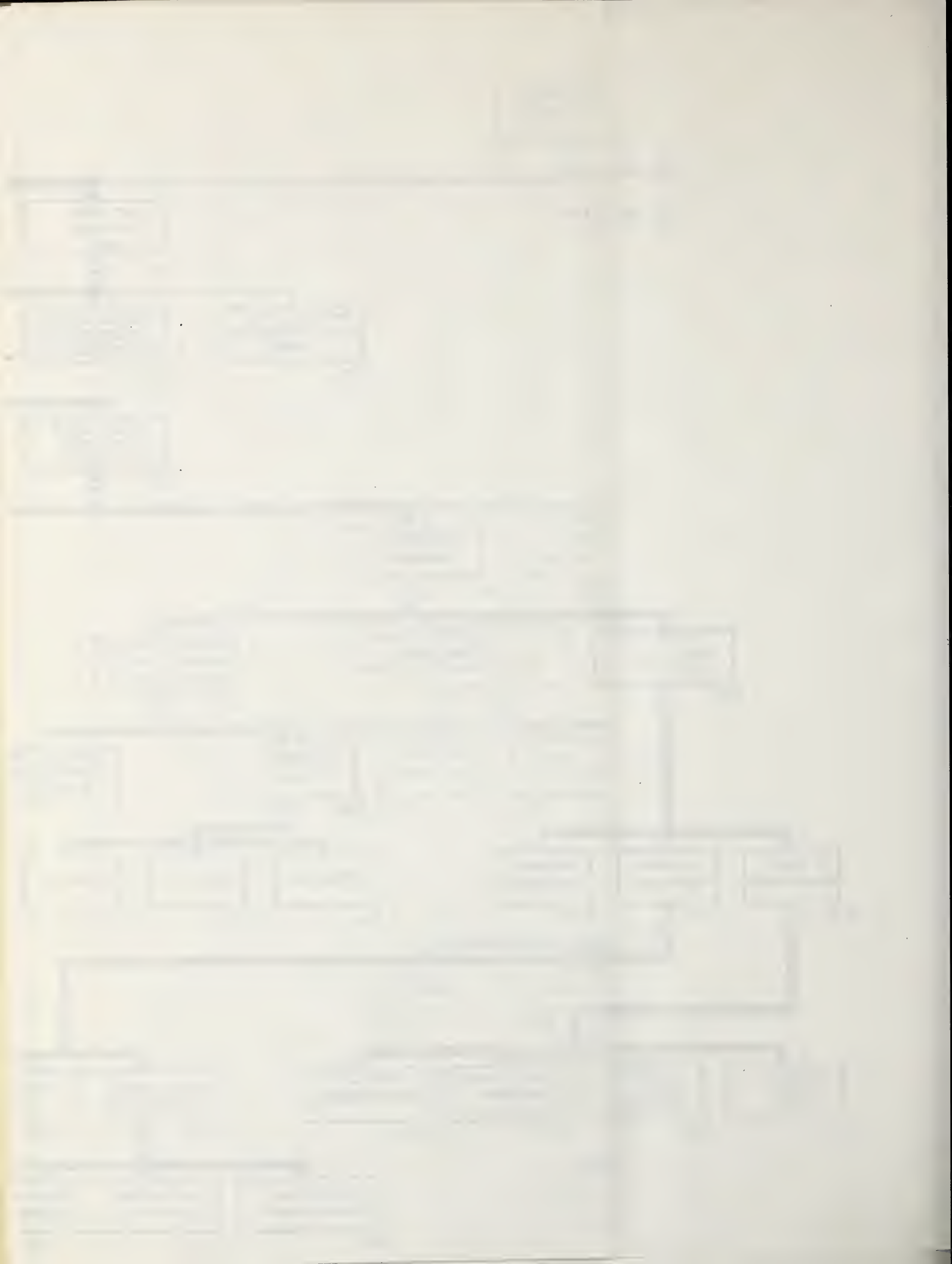


FIGURE III - 1.5

INJURY -

RESIDENTIAL FIRES

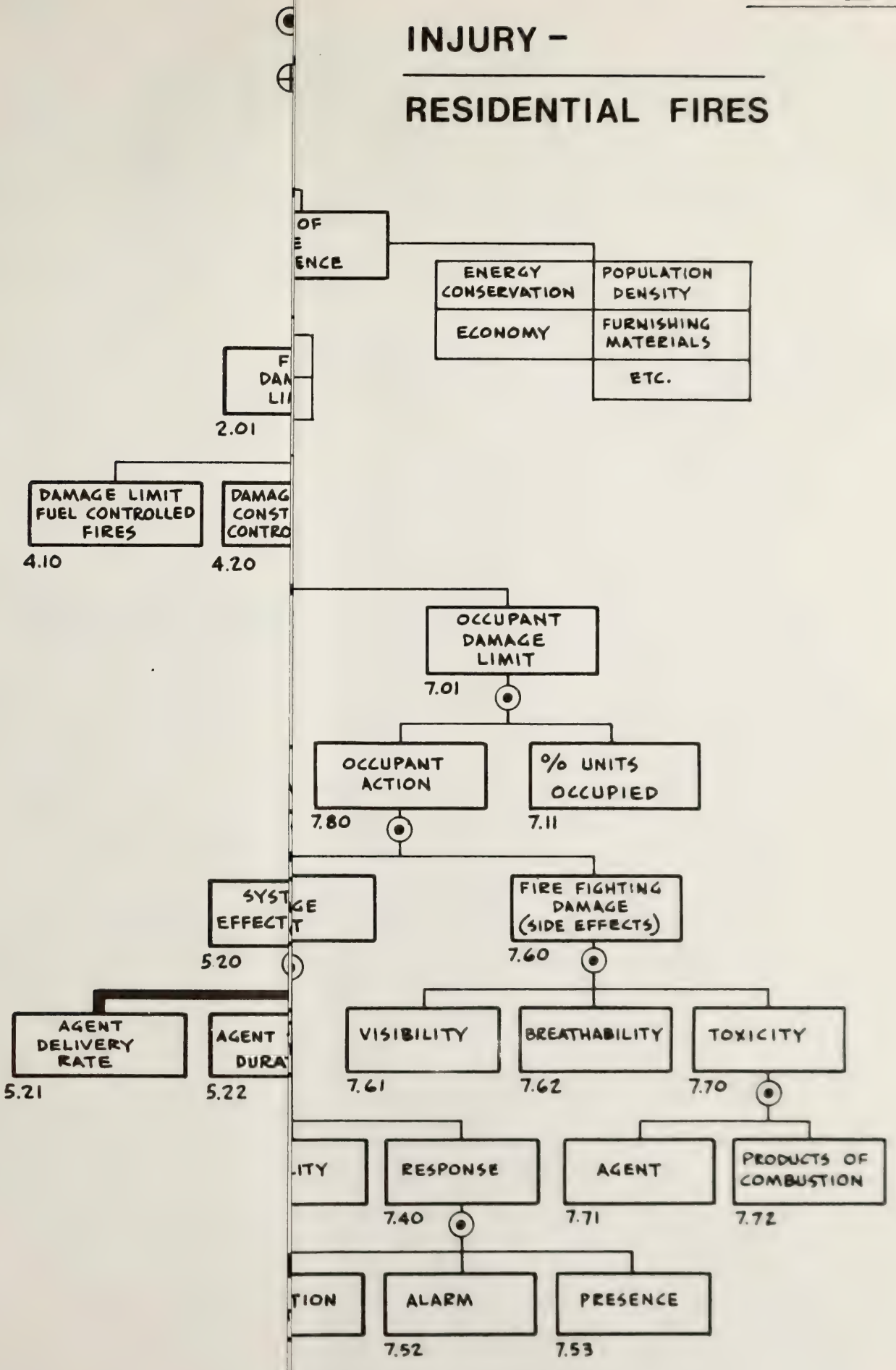
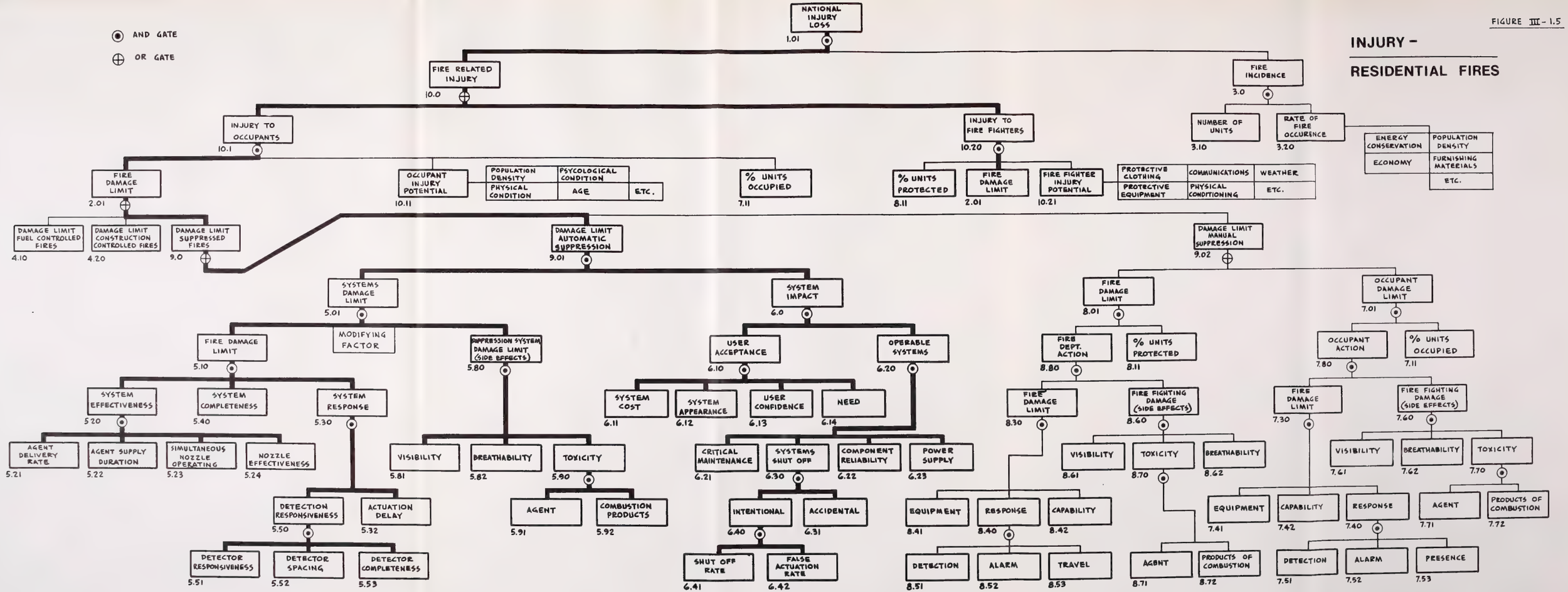


FIGURE III - 1.5

INJURY - RESIDENTIAL FIRES

⊙ AND GATE

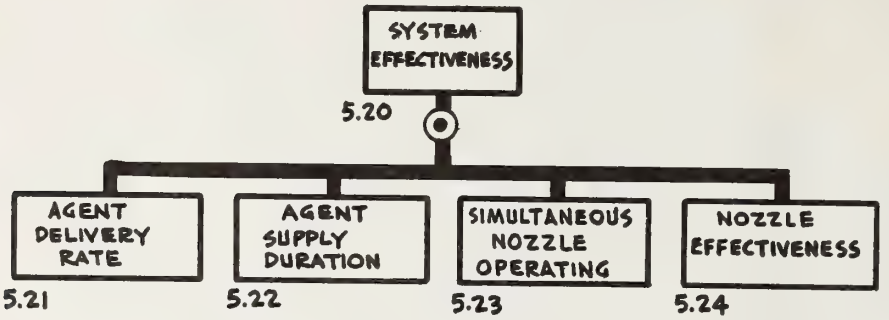
⊕ OR GATE



III-2 Property Loss - Discussion

III-2.1 Chart 5.20-AS System Effectiveness

III-2.1.1 Chart 5.20 is the product of Charts 5.21, 5.22, 5.23, and 5.24 which are combined through an "AND" gate as the factors referenced in the four contributory charts are all necessary for the successful operation of a sprinkler system. This chart illustrates the effectiveness of an automatic sprinkler system in controlling fire damage.



III-2.1.2 The chart is expressed as the probability of limiting fire damage to the point, room, unit, and building of origin. The same format is used with the other charts which deal with the ability to limit damage.

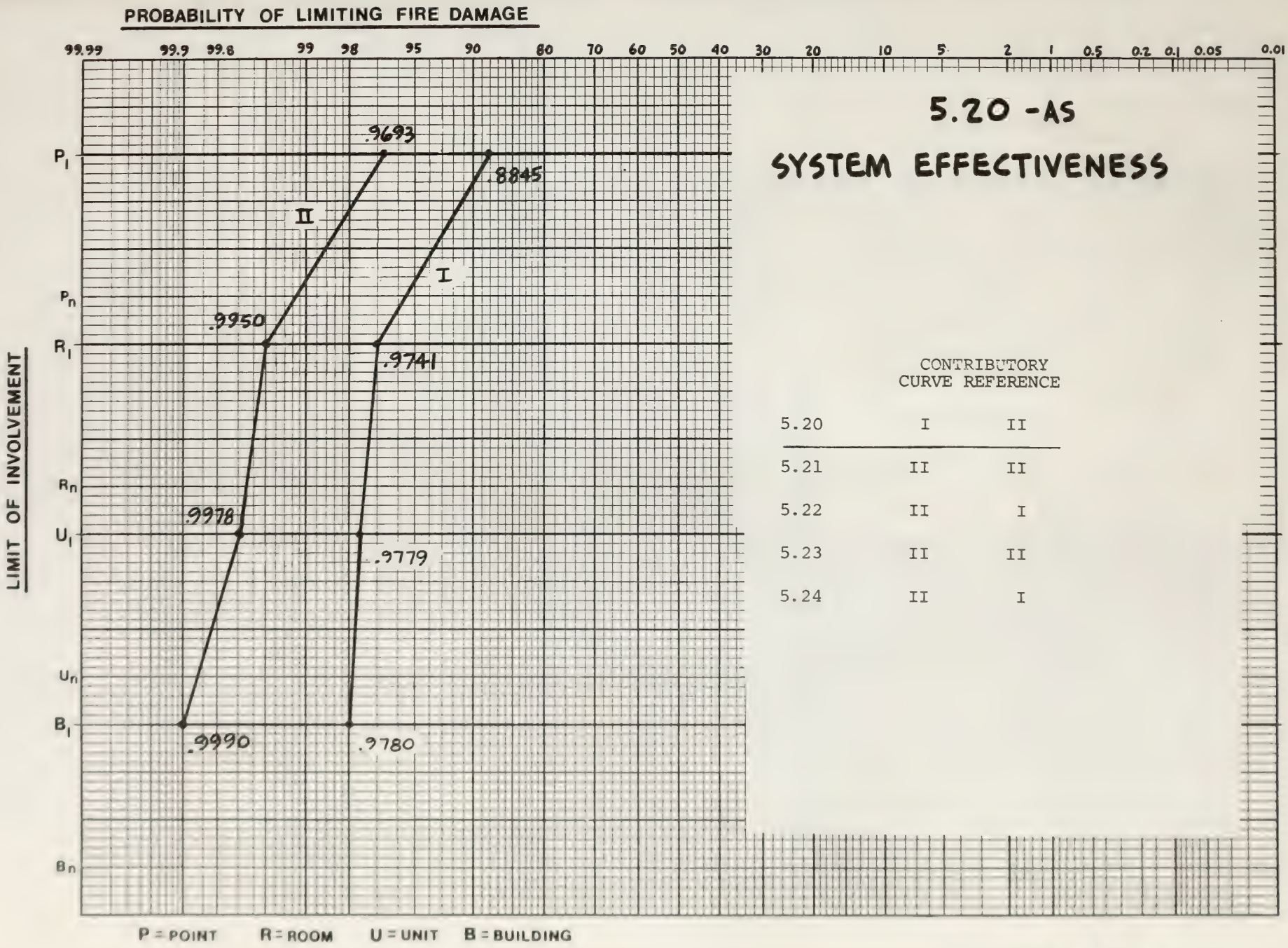
III-2.1.3 The chart considers three different types of systems:

- o Curve I represents a Level I system.
- o Curve II represents a Level II or Level III system.

III-2.1.4 It is estimated that the system defined by Curve I will control most residential fires, limiting fire damage to the point of origin in 88.45% of fires, to the room of origin in 97.41%, to the unit of origin in 97.79% and to the building of origin in 97.8%.

III-2.1.5 The percent of fires which will have fire damage occurring beyond the point of origin, but limited to within the room of origin can be obtained by subtracting the percent of fires which will have fire damage limited to the room from the percent of fires having damage limited to the point. As example, 8.96% of the fires will have damage occurring beyond the point of origin, but limited to within the room of origin (97.41 - 88.45 = 8.96). Similarly, 0.38% of the fires will have damage extending beyond the room of origin, but limited to within the unit of origin (97.79 - 97.41 = 0.38) and 0.01% of the fires will have damage extending beyond the unit of origin, but limited to within the building of origin (97.8 - 97.79 - 0.01).

III-2.1.6 2.2% of the fires will extend beyond the building of origin (100 - 97.8 = 2.2) if no other fire suppression measure occurs.



5.20 -AS

SYSTEM EFFECTIVENESS

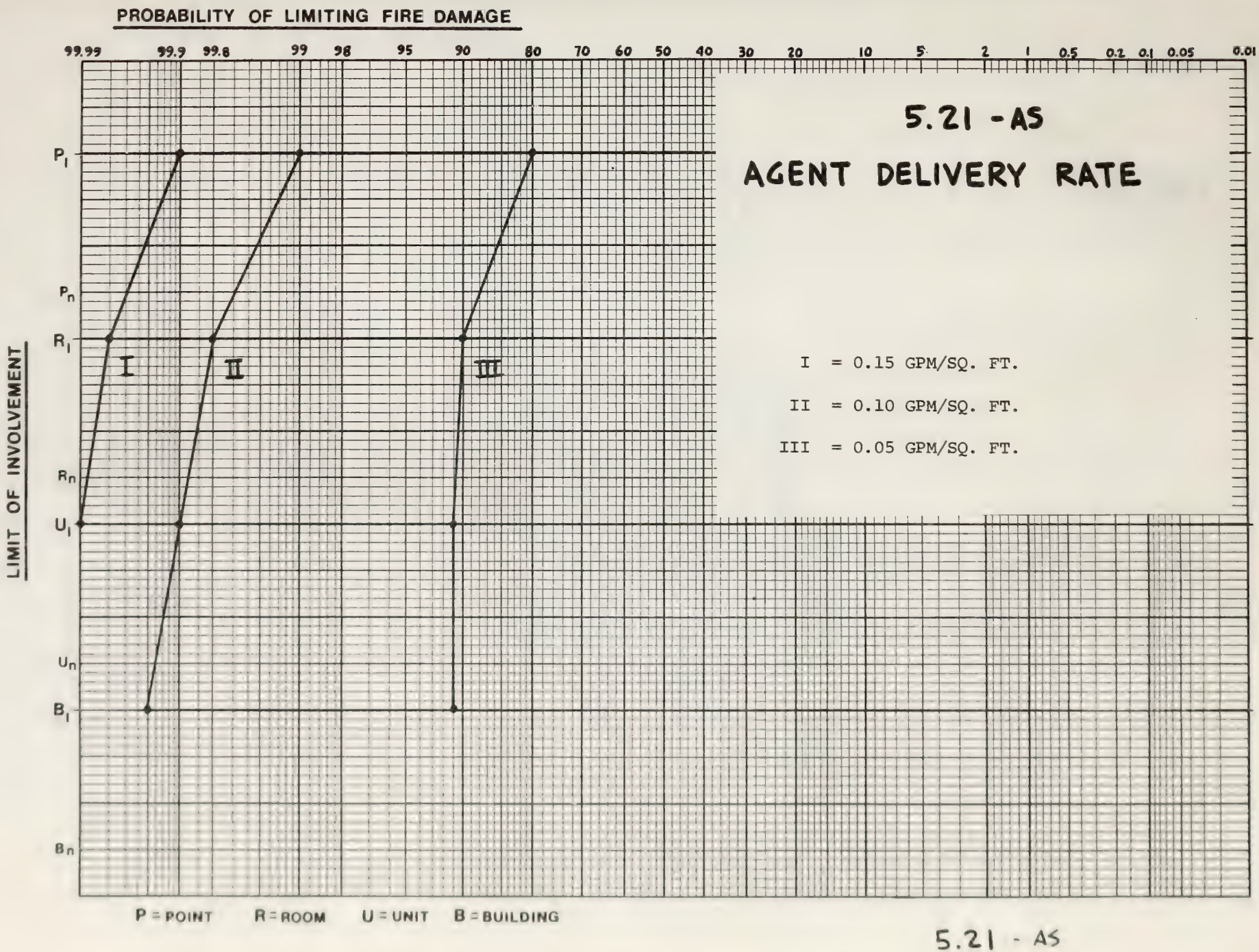
5.20	CONTRIBUTORY CURVE REFERENCE I	II
5.21	II	II
5.22	II	I
5.23	II	II
5.24	II	I

III-2.2 Chart 5.21-AS Agent Delivery Rate

III-2.2.1 Chart 5.21-AS provides an analysis of the effect of varying the rate of agent delivery on the extent of fire damage.

III-2.2.2 A density of 0.10 gpm per sq. ft. is considered adequate to control a residential fire with an acceptable degree of certainty (MAPL).

III-2.2.3 The curves were developed based on interpretation of the referenced fire research data, particularly the Factory Mutual Work (5, 13) and on automatic sprinkler performance records.

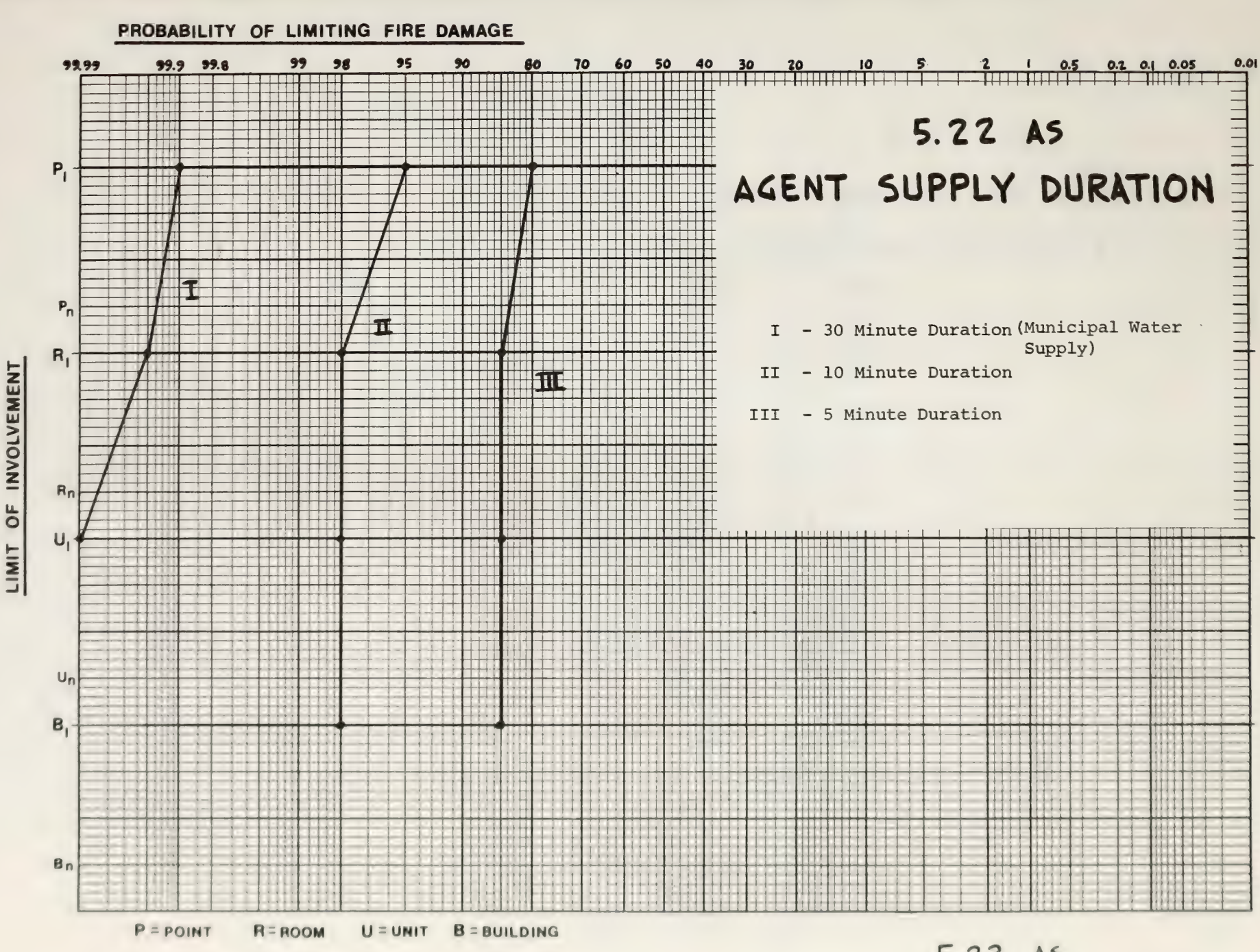

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.21 - AS
AGENT DELIVERY RATE
I = 0.15 GPM/SQ. FT.
II = 0.10 GPM/SQ. FT.
III = 0.05 GPM/SQ. FT.
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.3 Chart 5.22-AS Agent Supply Duration

III-2.3.1 Chart 5.22-AS illustrates the effect of varying the duration of system discharge on the extent of fire damage.

III-2.3.2 A minimum 10 minute agent supply duration is considered acceptable for a Residential Automatic Sprinkler System (MAPL).

III-2.3.3 These curves are based upon interpretation of the referenced fire research data, particularly data dealing with fire growth rates. No data was available dealing directly with the question of agent supply duration.



5.22 AS
AGENT SUPPLY DURATION

I - 30 Minute Duration (Municipal Water Supply)

II - 10 Minute Duration

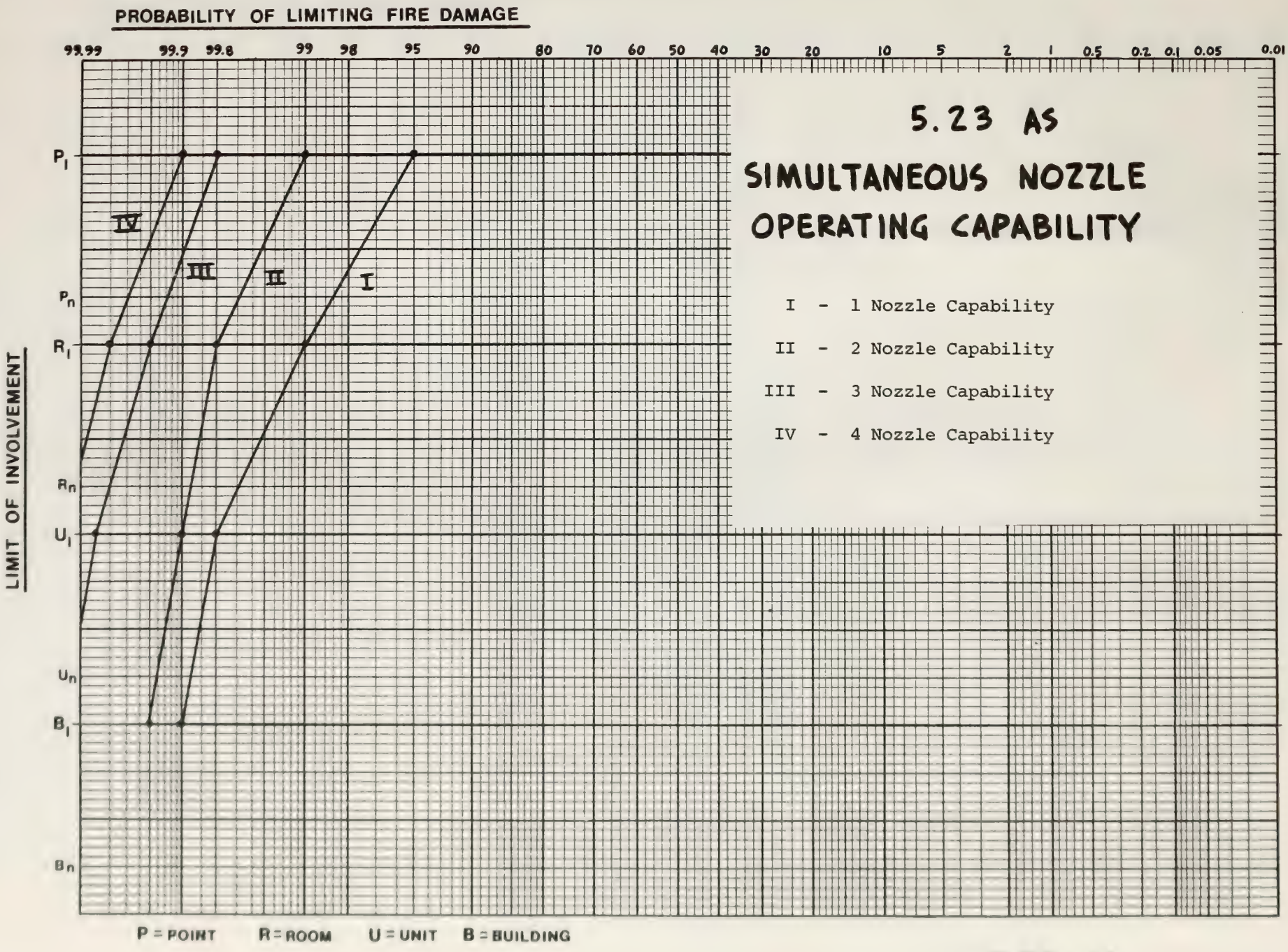
III - 5 Minute Duration

III.2.4 Chart 5.23-AS Simultaneous Nozzle Operating Capability

III-2.4.1 Chart 5.23-AS shows the effect of varying the number of nozzles which can operate simultaneously on the extent of fire damage.

III-2.4.2 The minimum number of nozzles operating simultaneously considered acceptable is two because of the possibility of fire occurring between two rooms or between two nozzles (MAPL).

III-2.4.3 The curves are based on judgment considering the existing NFPA sprinkler performance records (35) and the possibility of fire operating more than one sprinkler.



5.23 AS

SIMULTANEOUS NOZZLE OPERATING CAPABILITY

I - 1 Nozzle Capability

II - 2 Nozzle Capability

III - 3 Nozzle Capability

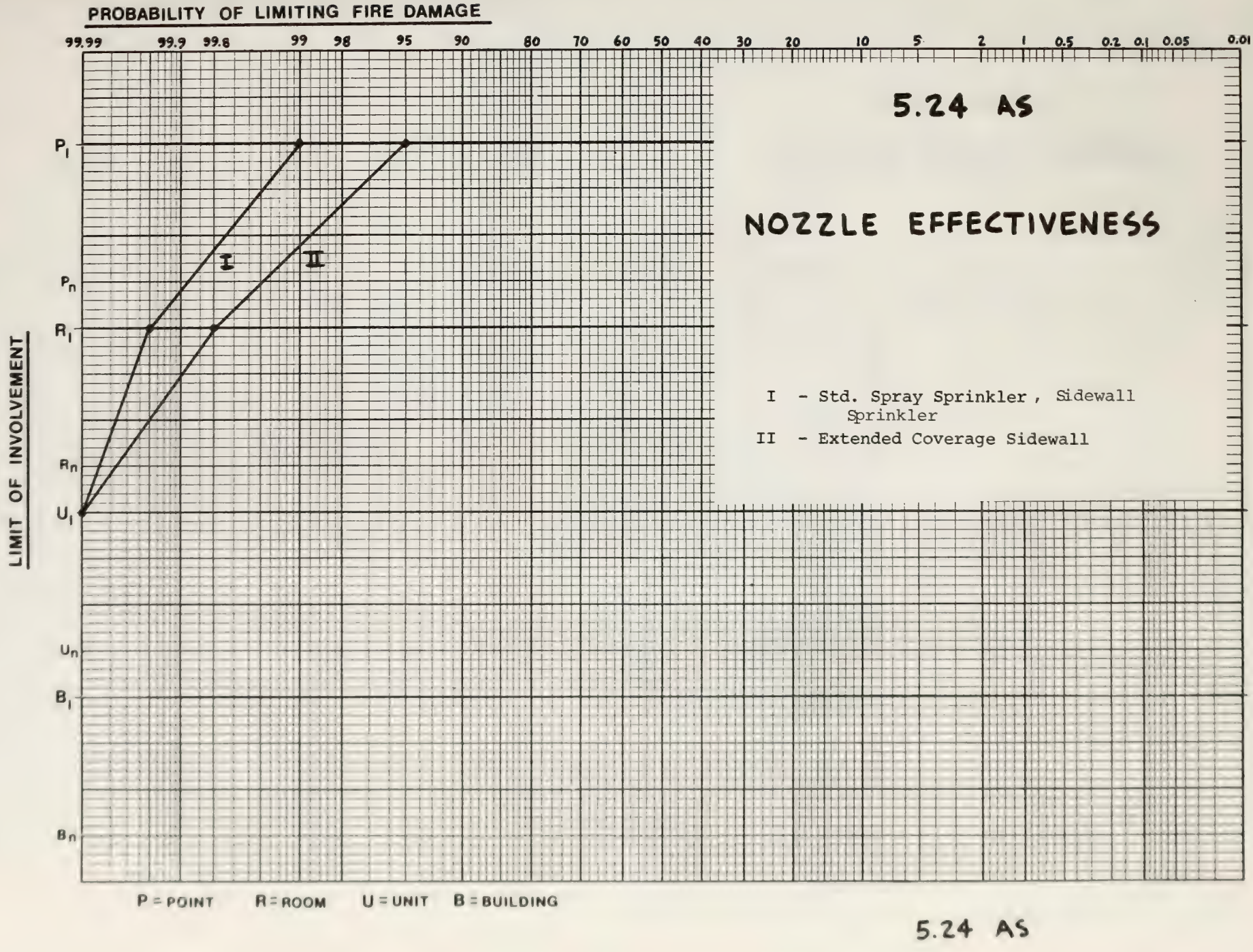
IV - 4 Nozzle Capability

III-2.5 - Chart 5.24-AS Nozzle Effectiveness

III-2.5.1 This chart shows the influence of nozzle extinguishing effectiveness for a standard sprinkler, a sidewall sprinkler and an extended coverage sidewall sprinkler on the extent of fire damage.

III-2.5.2 Either the standard sprinkler, sidewall sprinkler or the extended coverage sidewall sprinkler are considered acceptable (MAPL).

III-2.5.3 The curves are based on judgment considering sprinkler performance records and the Underwriters Laboratories Inc. sprinkler test procedure - Subject 199 (89).

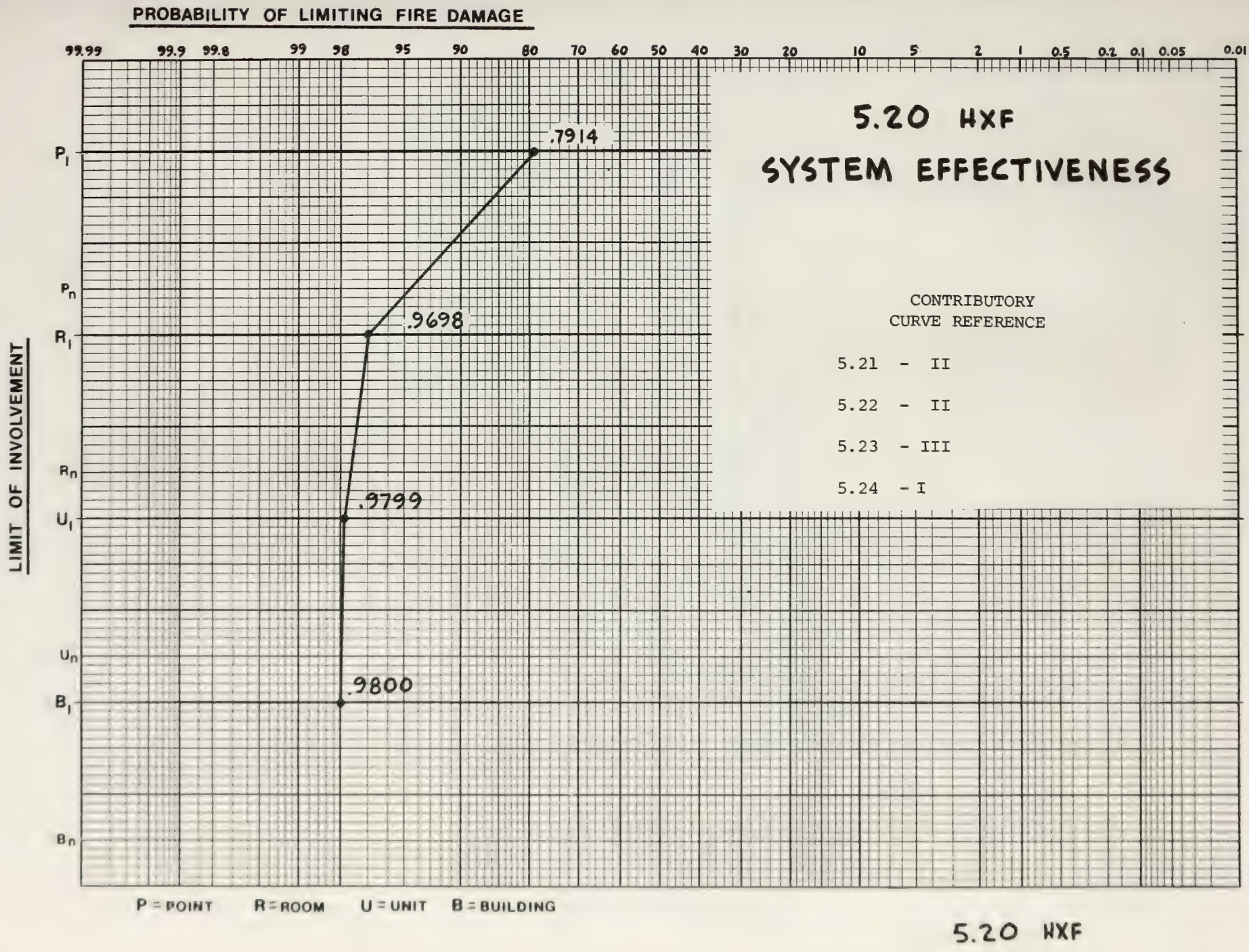

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
II
5.24 AS
NOZZLE EFFECTIVENESS
I - Std. Spray Sprinkler, Sidewall Sprinkler
II - Extended Coverage Sidewall
P = POINT R = ROOM U = UNIT B = BUILDING

5.24 AS

III-2.6 - Chart 5.20-HXF System Effectiveness

III-2.6.1 Chart 5.20-HXF shows the effectiveness of a high expansion foam system in controlling fire. It is somewhat less effective in controlling damage to the point of origin than the sprinkler system expressed on Chart 5.20-AS. It is as effective in controlling fire damage beyond the room of origin as the sprinkler system.

III-2.6.2 The curves on Chart 5.20 HXF are derived in the same fashion as the curves on Chart 5.20 AS, i.e., the product of the contributory curves 5.21 HXF, 5.22 HXF, 5.23 HXF, 5.24 HXF all combined through an "AND" gate.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.7914
.9698
.9799
.9800
5.20 HXF
SYSTEM EFFECTIVENESS
CONTRIBUTORY
CURVE REFERENCE
5.21 - II
5.22 - II
5.23 - III
5.24 - I
P = POINT
R = ROOM
U = UNIT
B = BUILDING

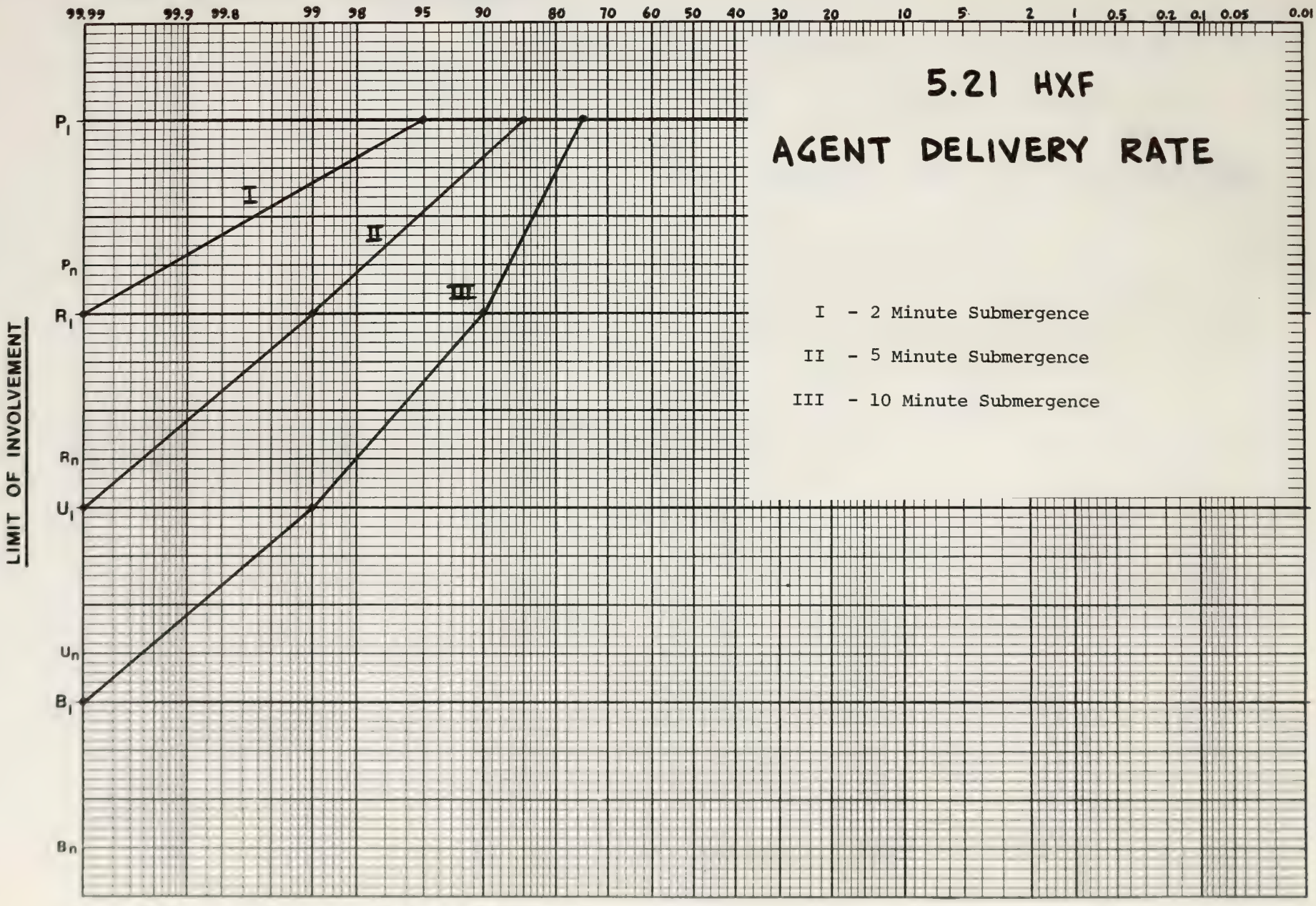
5.20 HXF

III-2.7 - Chart 5.21-HXF Agent Delivery Rate

III-2.7.1 Chart 5.21-HXF shows the effect of varying the fill rate for a high expansion foam system on the extent of fire damage.

III-2.7.2 A 5 minute fill time is considered as the minimum acceptable fill time (MAPL).

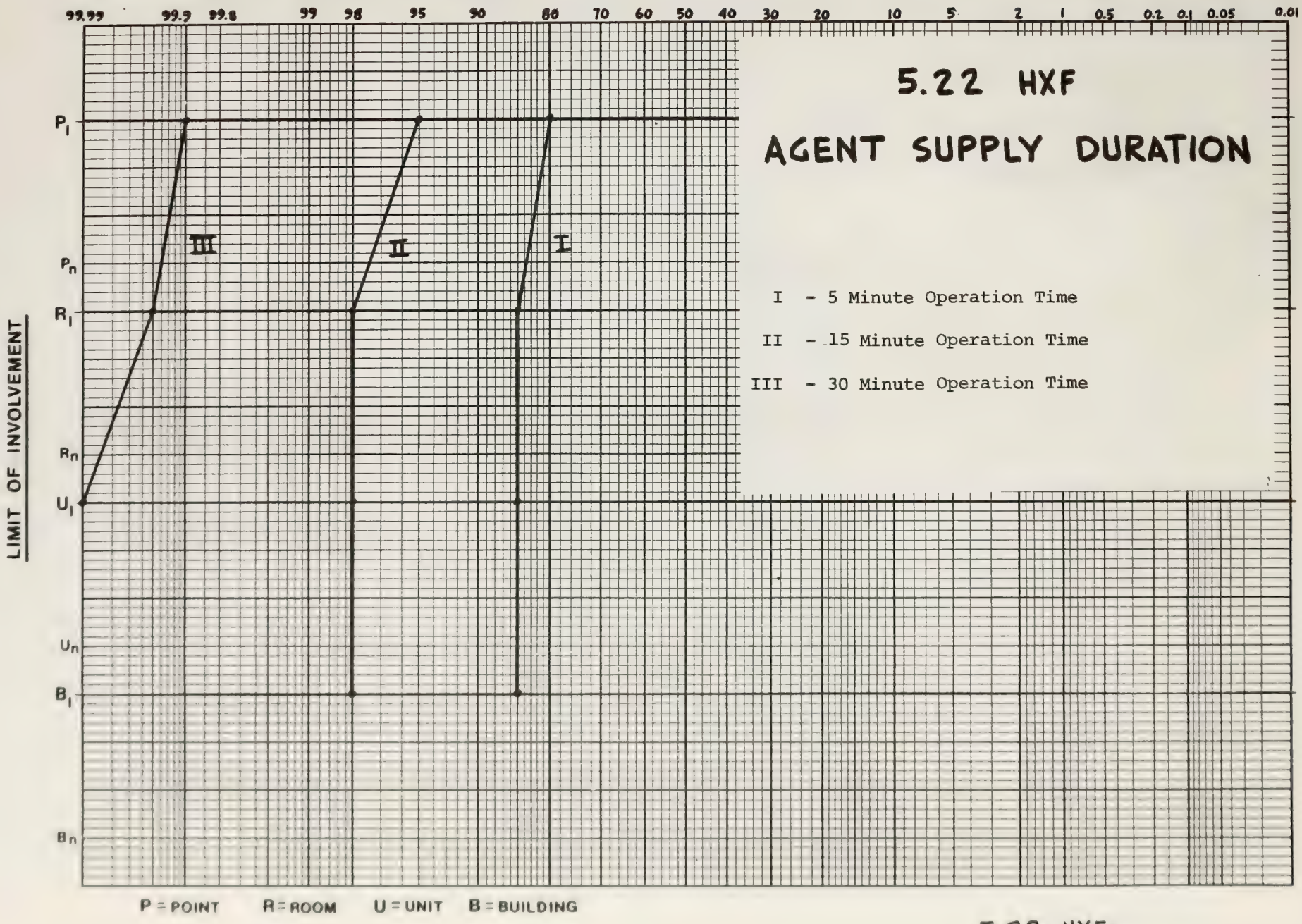
III-2.7.3 The curves are based on judgment considering fire research data relating to the development of fire and on submergence times contained in NFPA Standard IIA-1970 Edition (56).


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.21 HXF
AGENT DELIVERY RATE
I - 2 Minute Submergence
II - 5 Minute Submergence
III - 10 Minute Submergence
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.21 HXF

III-2.8 - Chart 5.22-HXF Agent Supply Duration

Chart 5.22-HXF is similar to Chart 5.22-AS and is based on judgment, considering NFPA Standard 11-A - 1970 Edition (56) requirements.

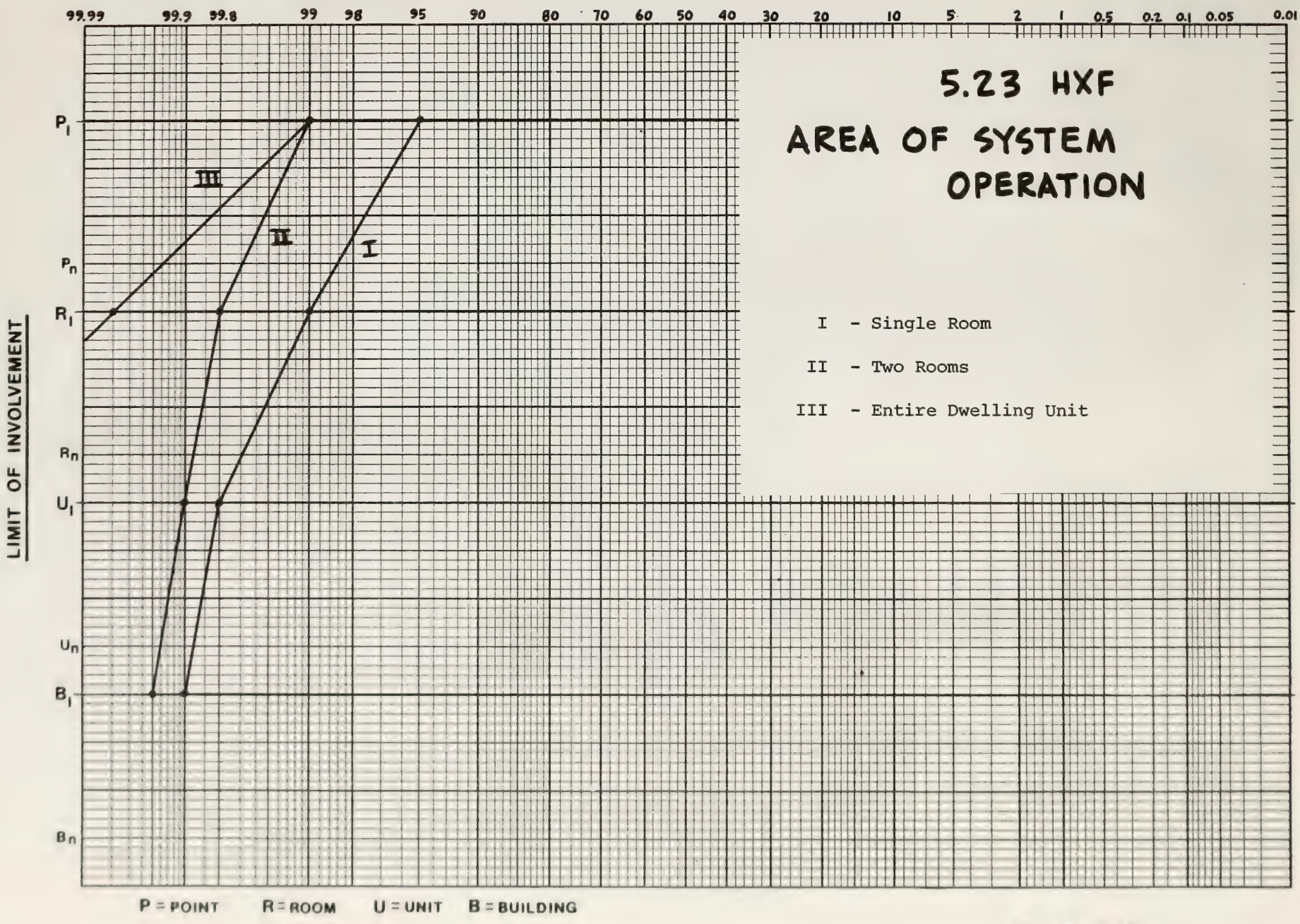

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
III
II
I
5.22 HXF
AGENT SUPPLY DURATION
I - 5 Minute Operation Time
II - 15 Minute Operation Time
III - 30 Minute Operation Time
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.9 - Chart 5.23-HXF Area of System Operation

III-2.9.1 Chart 5.23-HXF shows the ability of the system to limit fire damage as a function of the system ability to simultaneously discharge in one room, two rooms or the entire residence.

III-2.9.2 Because the system is a total flooding system, it needs to be able to discharge throughout the entire residence at one time (MAPL).

III-2.9.3 The curves are based upon judgment of the probability of fire occuring in an area between two or more rooms.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
III
II
I
5.23 HXF
AREA OF SYSTEM OPERATION
I - Single Room
II - Two Rooms
III - Entire Dwelling Unit
P = POINT
R = ROOM
U = UNIT
B = BUILDING

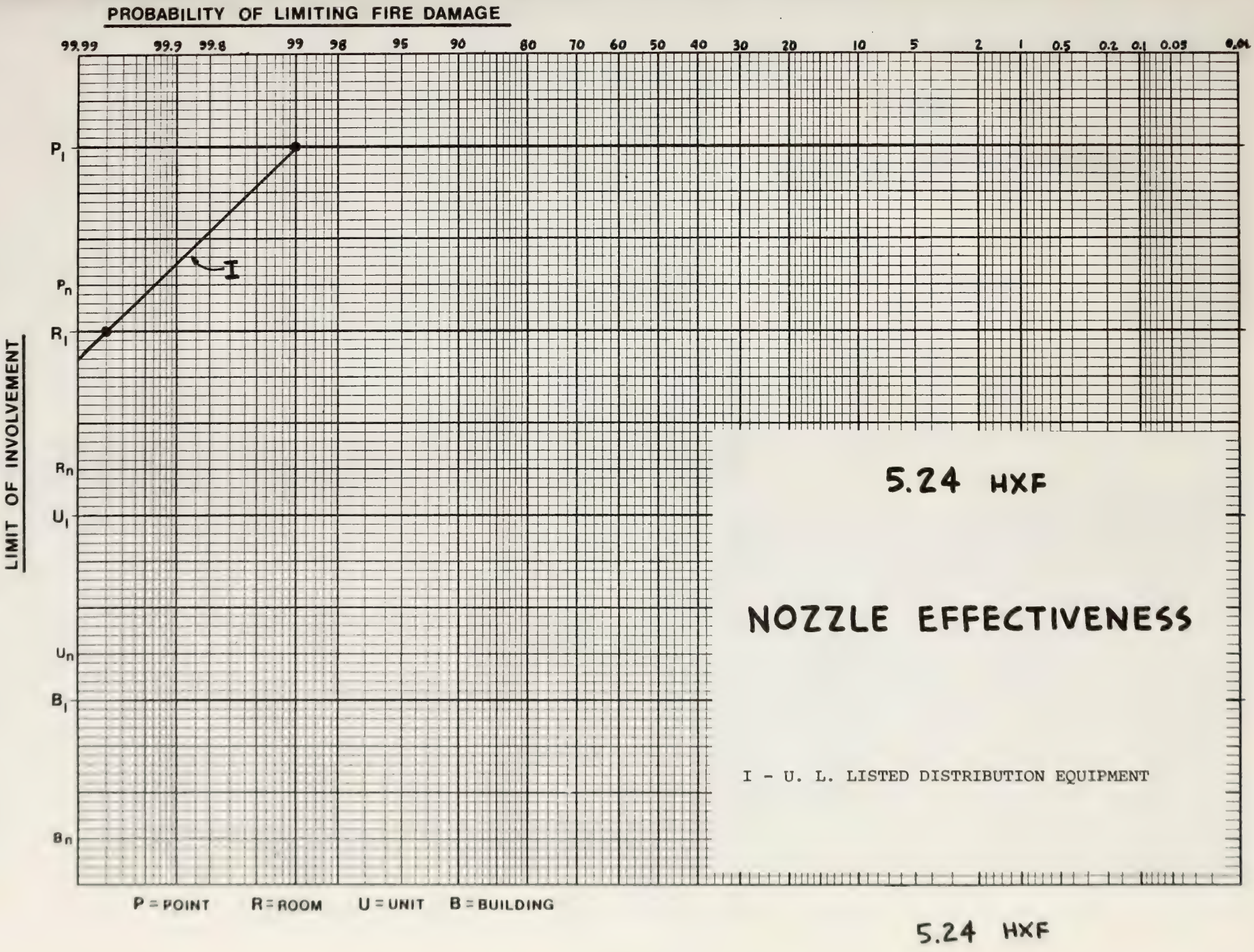
5.23 HXF

III-2.10 - Chart 5.24-HXF Nozzle Effectiveness

III-2.10.1 Chart 5.24 HXF shows the impact of nozzle effectiveness in limiting fire damage.

III-2.10.2 UL listed discharge "nozzles" and delivery equipment are needed (MAPL).

III-2.10.3 The curve is based on judgment considering NFPA Standard 11A - 1970 Edition (56).

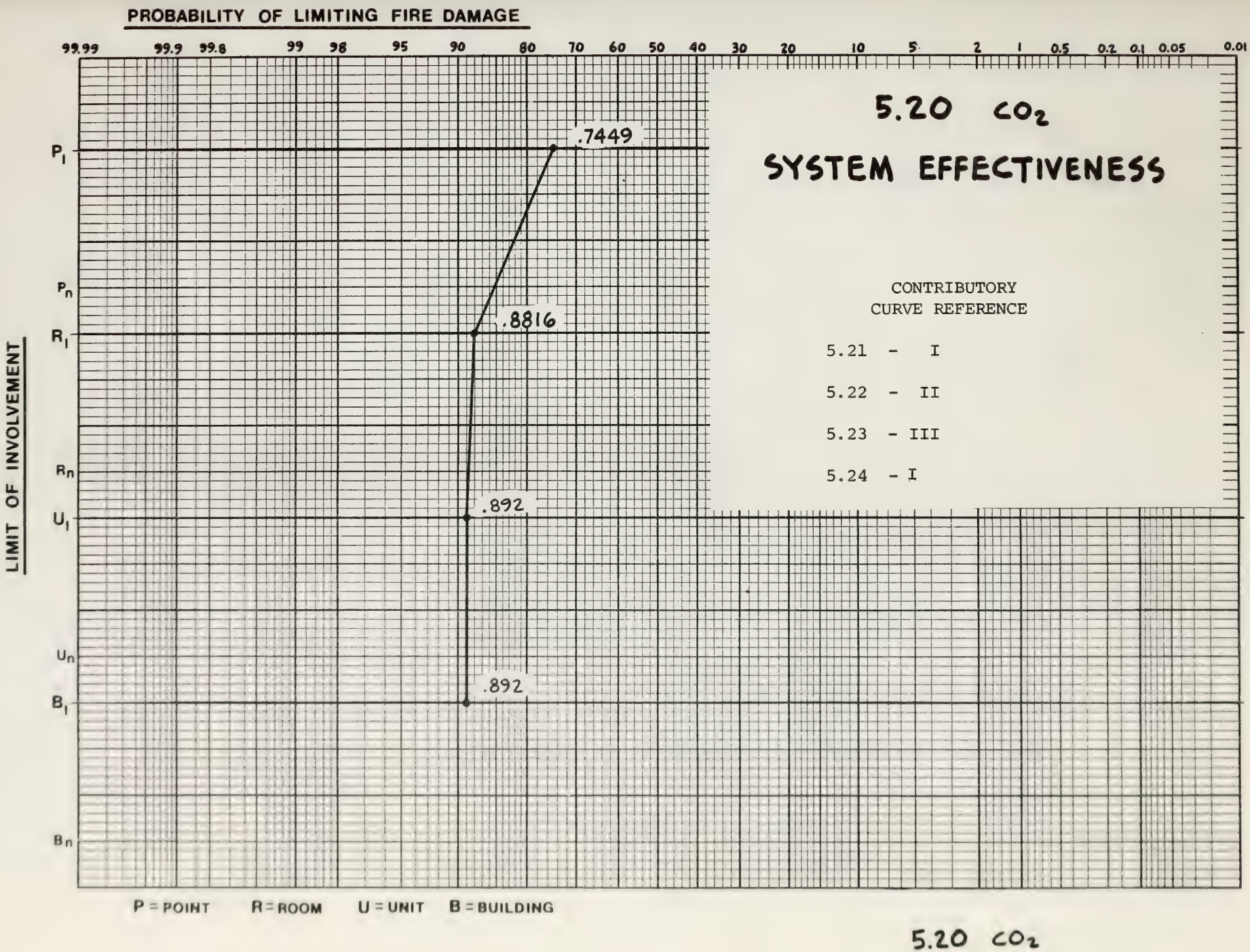

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
5.24 HXF
NOZZLE EFFECTIVENESS
I - U. L. LISTED DISTRIBUTION EQUIPMENT
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.24 HXF

III-2.11 Chart 5.20-CO2 System Effectiveness

III-2.11.1 Chart 5.20-CO2 shows that the carbon dioxide system is somewhat less effective than either the high expansion foam or the sprinkler system in controlling fire damage.

III-2.11.2 The curve on Chart 5.20 CO2 was developed in the same fashion as the curves on Charts 5.20 AS and 5.20 HXF.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.7449
.8816
.892
.892
5.20 CO2
SYSTEM EFFECTIVENESS
CONTRIBUTORY
CURVE REFERENCE
5.21 - I
5.22 - II
5.23 - III
5.24 - I
P = POINT
R = ROOM
U = UNIT
B = BUILDING

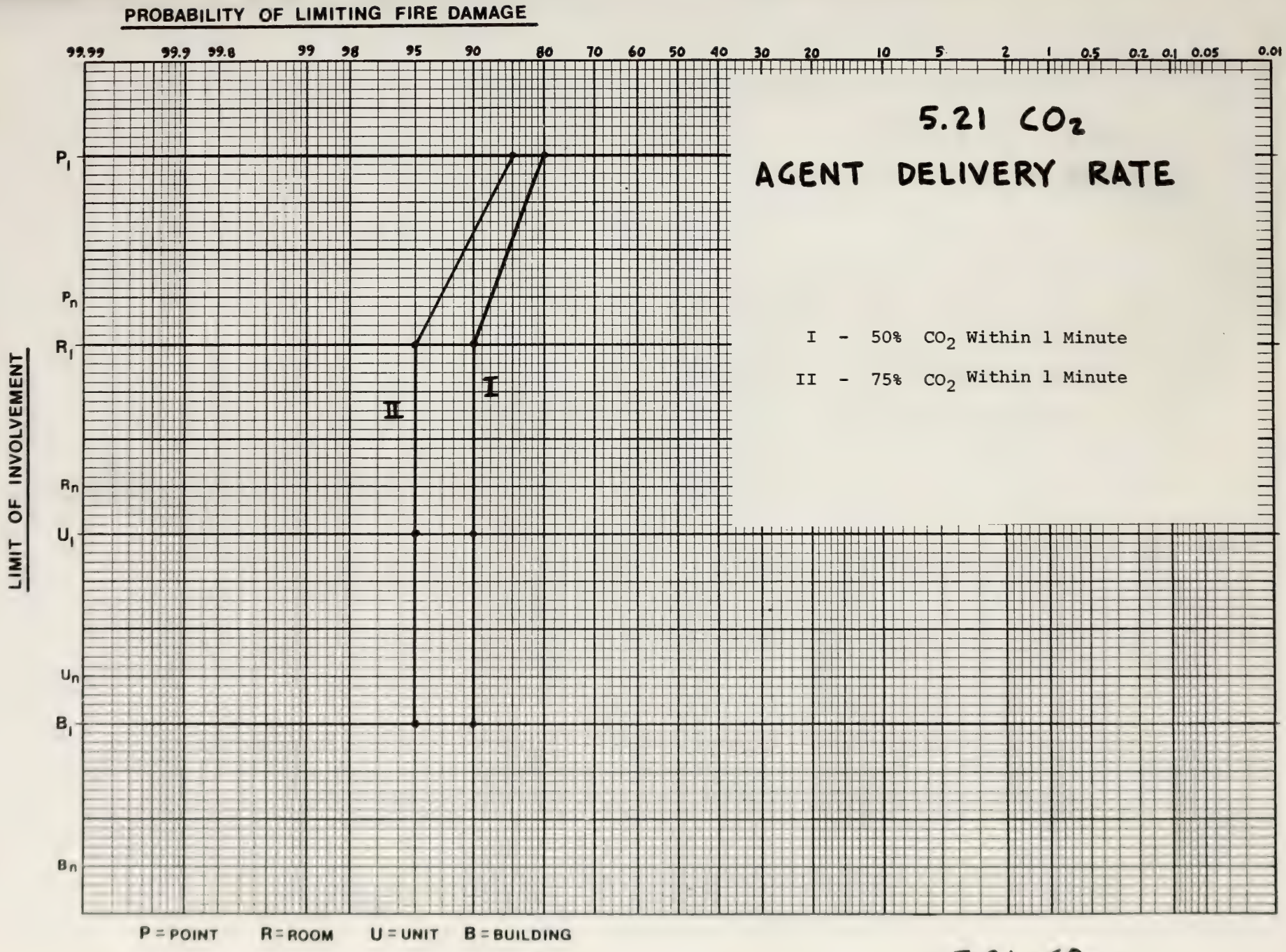
5.20 CO_2

III-2.12 - Chart 5.21-CO2 Agent Delivery Rate

III-2.12.1 Chart 5.21-CO2 shows the effect of agent delivery rate on fire damage.

III-2.12.2 A minimum 50% CO2 concentration within 1 minute of discharge is considered to be an acceptable delivery rate (MAPL).

III-2.12.3 The curves are based on judgment of the reported extinguishing ability of carbon dioxide on Class "A" fires and on NFPA Standard 12, 1973 Edition (57).


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
5.21 CO2
AGENT DELIVERY RATE
I - 50% CO2 Within 1 Minute
II - 75% CO2 Within 1 Minute
P = POINT
R = ROOM
U = UNIT
B = BUILDING

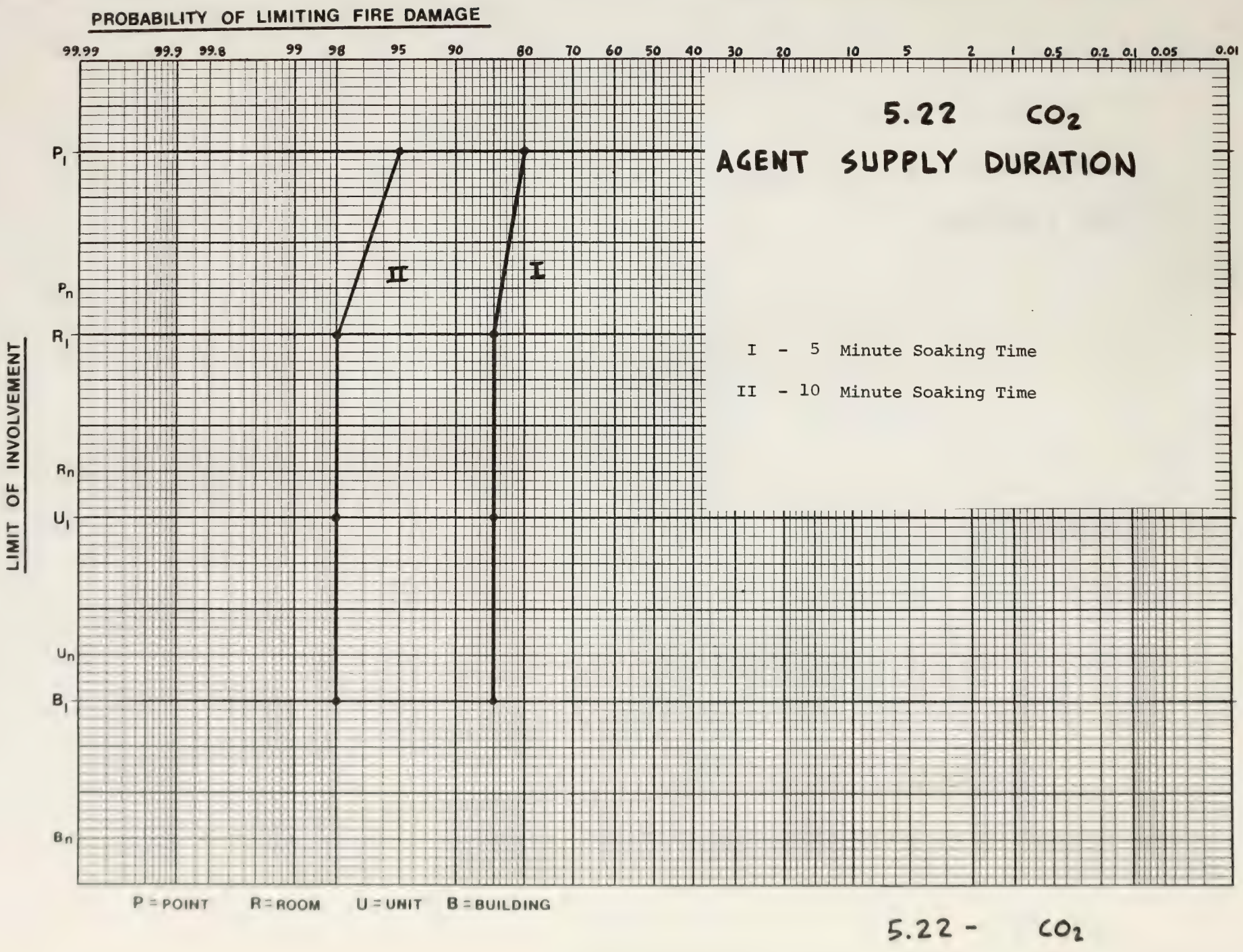
5.21 CO_2

III-2.13 - Chart 5.22-CO2 Agent Supply Duration

III-2.13.1 Chart 5.22-CO2 shows the effect of the post-discharge soaking period, during which the agent design concentration is maintained, on the extent of fire damage.

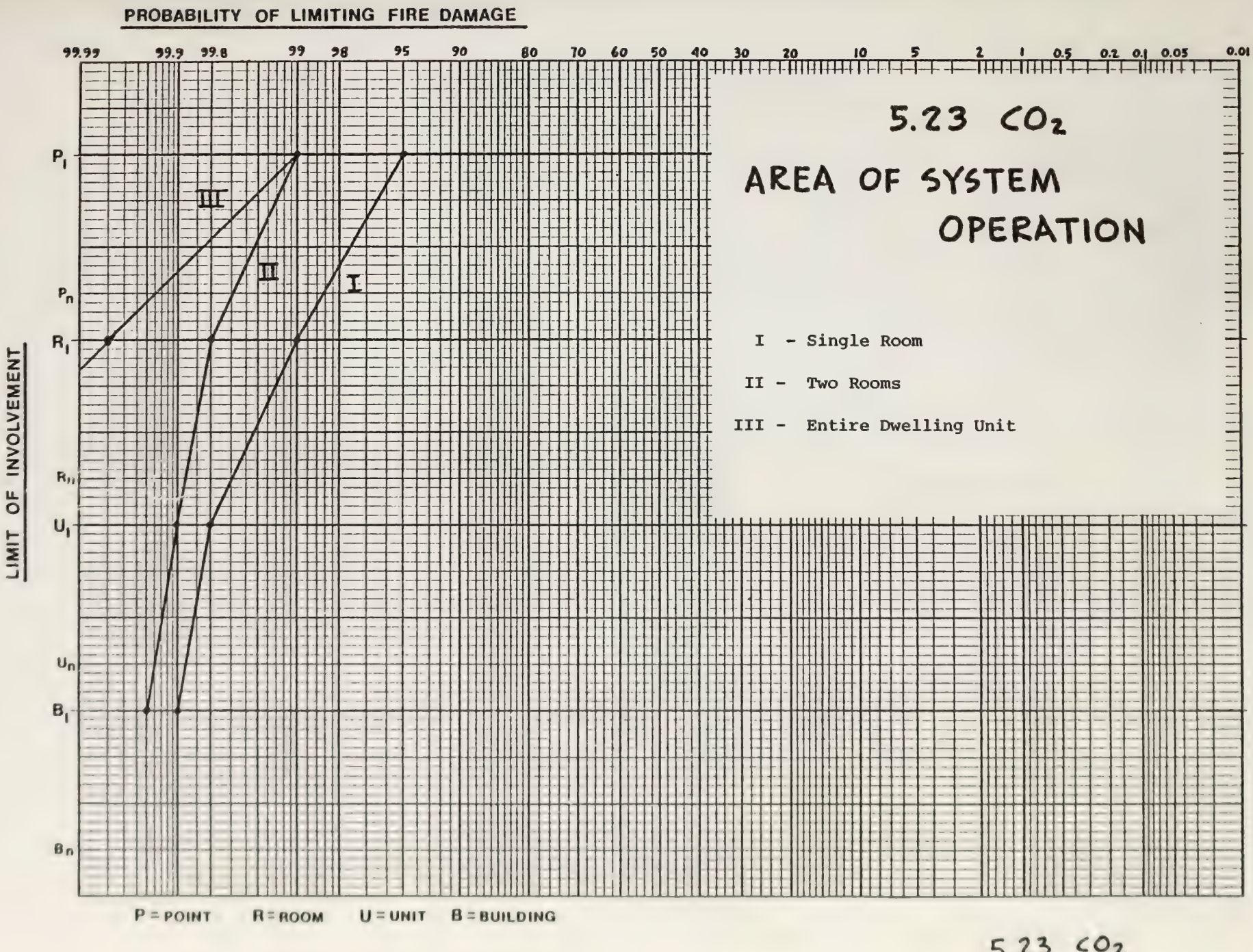
III-2.13.2 A minimum 10 minute soaking period is considered to be acceptable (MAPL).

III-2.13.3 The curves are based on judgment of the ability of carbon dioxide to extinguish a deep-seated, Class "A" fire.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
II
I
5.22 CO2
AGENT SUPPLY DURATION
I - 5 Minute Soaking Time
II - 10 Minute Soaking Time
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.14 - Chart 5.23-CO2 Area of System Operation

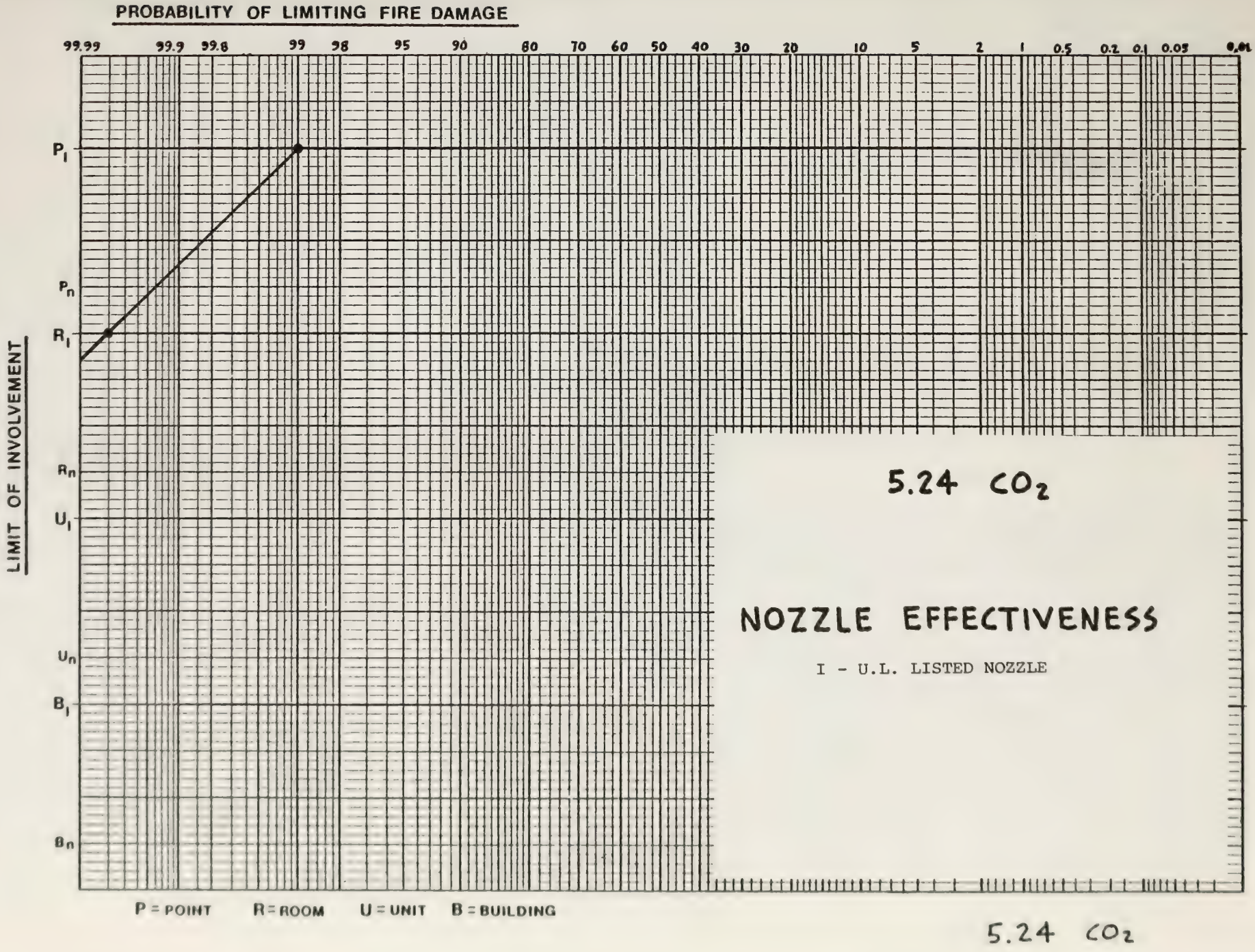
Chart 5.23-CO2 is identical to Chart 5.23-HXF.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
III
II
I
5.23 CO2
AREA OF SYSTEM OPERATION
I - Single Room
II - Two Rooms
III - Entire Dwelling Unit
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.23 CO_2

III-2.15 - Chart 5.24-CO2 Nozzle Effectiveness

Chart 5.24-CO2 is identical to Chart 5-24-HXF.

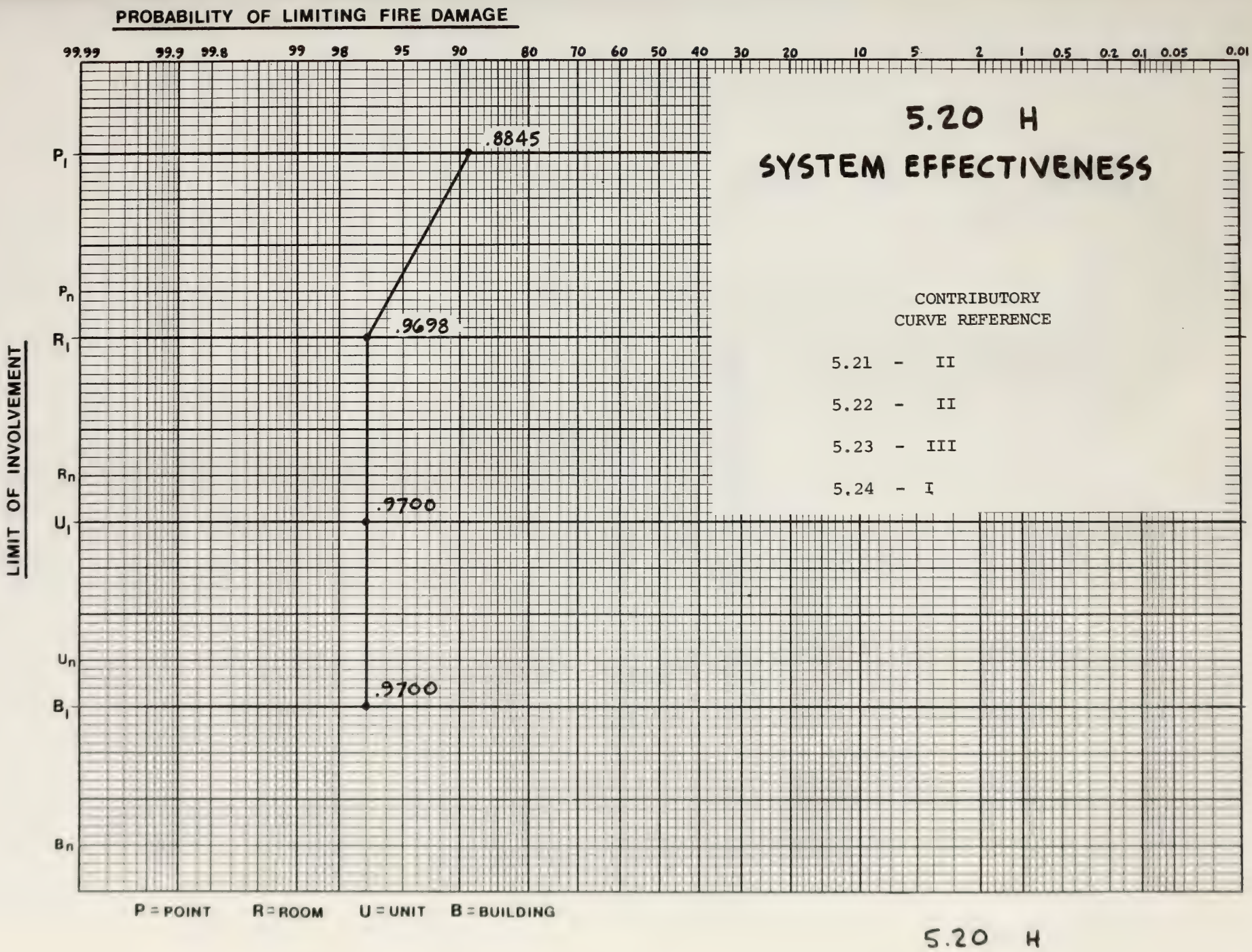

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_1
P_n
R_1
R_n
U_1
U_n
B_1
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
5.24 CO_2
NOZZLE EFFECTIVENESS
I - U.L. LISTED NOZZLE

5.24 CO_2

III-2.16 - Chart 5.20-H System Effectiveness

III-2.16.1 Chart 5.20-H shows the effectiveness of Halon 1301 systems in controlling fire damage. The Halon system is comparable to the sprinkler system in that respect.

III-2.16.2 The curve on Chart 5.20 H was developed in the same fashion as the previously discussed 5.20 AS curve.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.8845
.9698
.9700
.9700
5.20 H
SYSTEM EFFECTIVENESS
CONTRIBUTORY
CURVE REFERENCE
5.21 - II
5.22 - II
5.23 - III
5.24 - I
P = POINT R = ROOM U = UNIT B = BUILDING

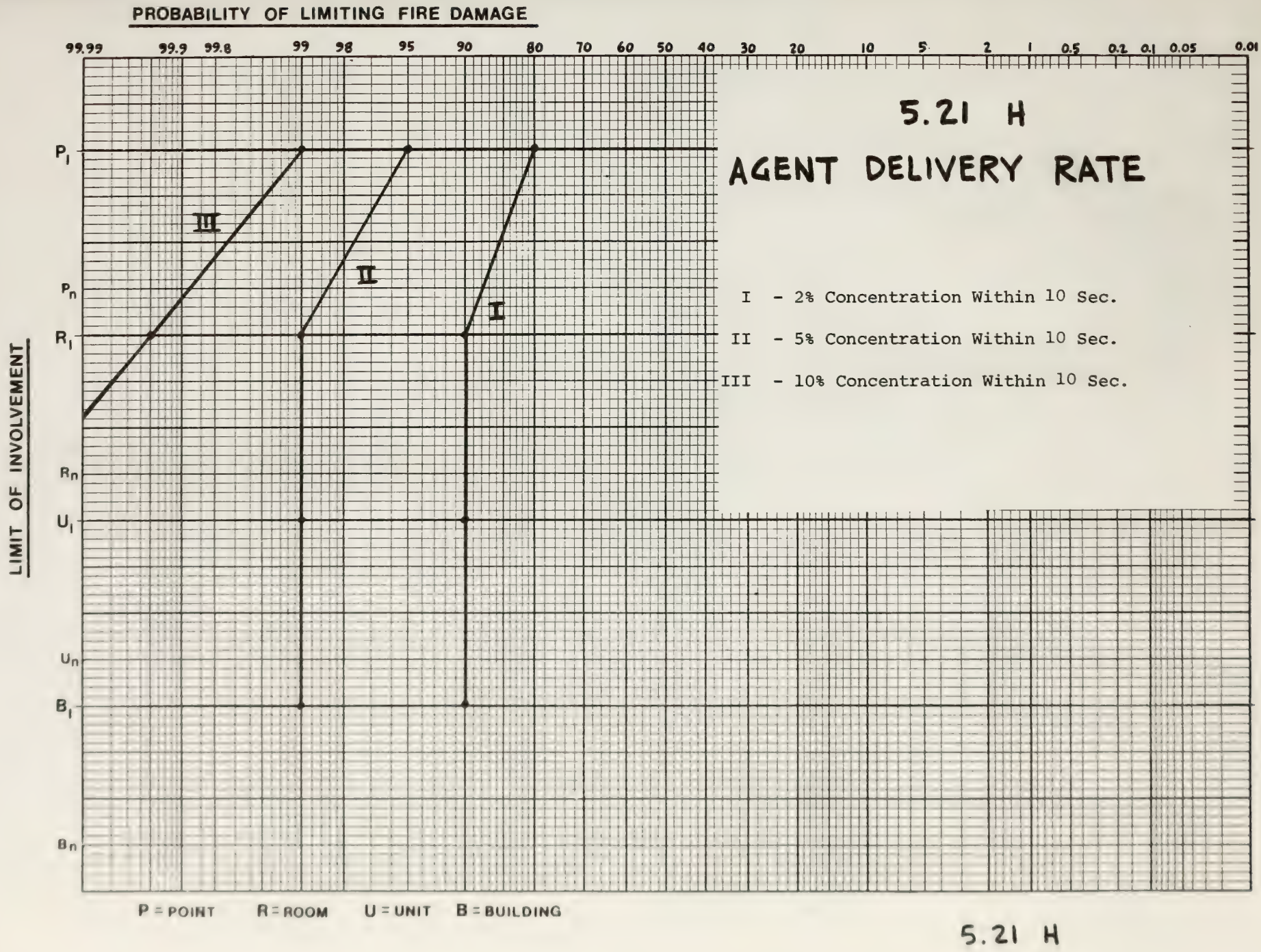
5.20 H

III-2.17 - Chart 5.21-H Agent Delivery Rate

III-2.17.1 Chart 5.21-H shows the effect of the agent delivery rate in limiting fire damage.

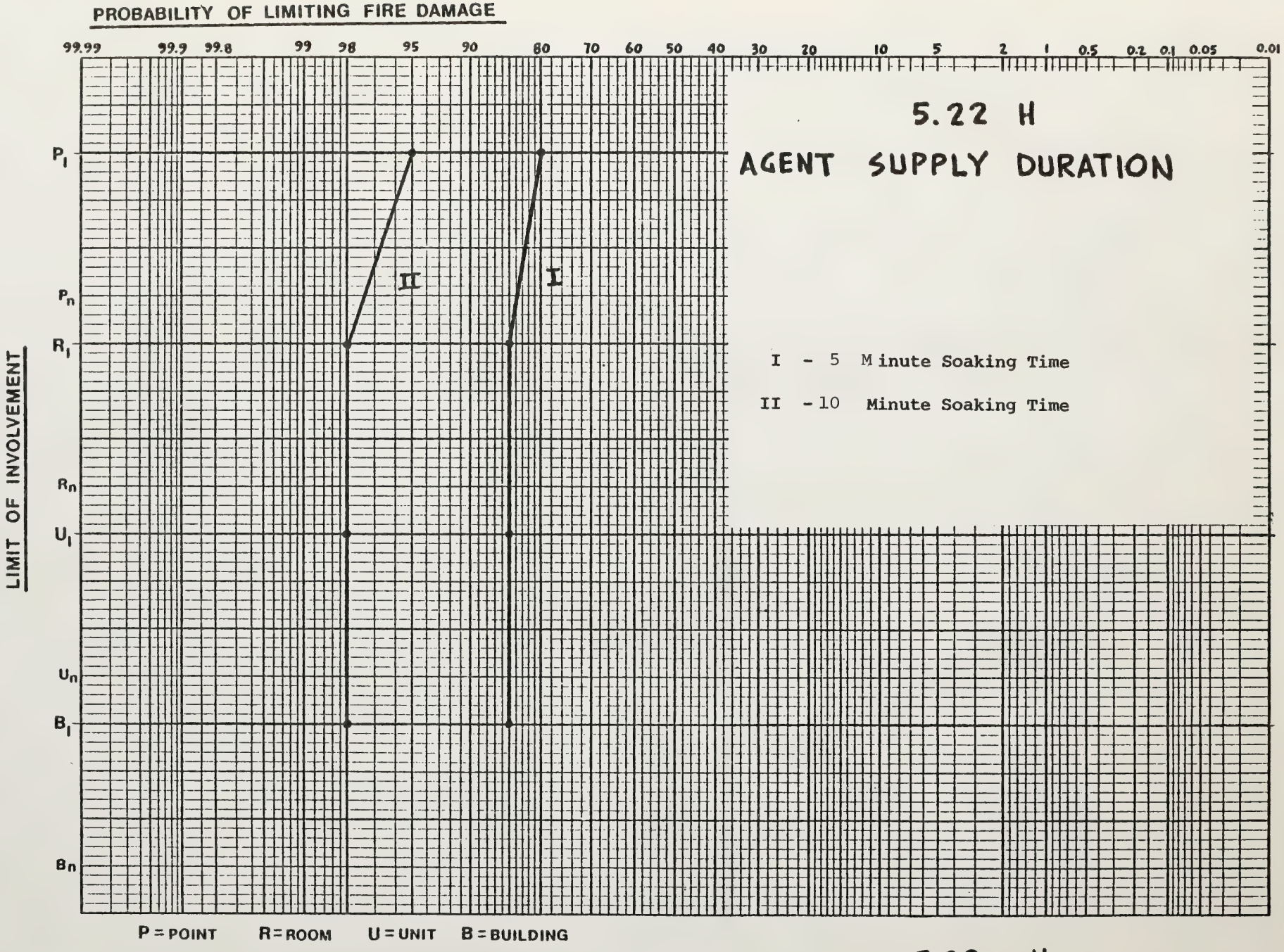
III-2.17.2 A minimum 5% concentration within 10 seconds of system discharge is considered acceptable (MAPL).

III-2.17.3 The curve is based on judgment of available fire test information regarding the ability of Halon 1301 to extinguish Class "A" fires and on NFPA Standard 12A - 1975 Edition (58).


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.21 H
AGENT DELIVERY RATE
I - 2% Concentration Within 10 Sec.
II - 5% Concentration Within 10 Sec.
III - 10% Concentration Within 10 Sec.
P = POINT
R = ROOM
U = UNIT
B = BUILDING

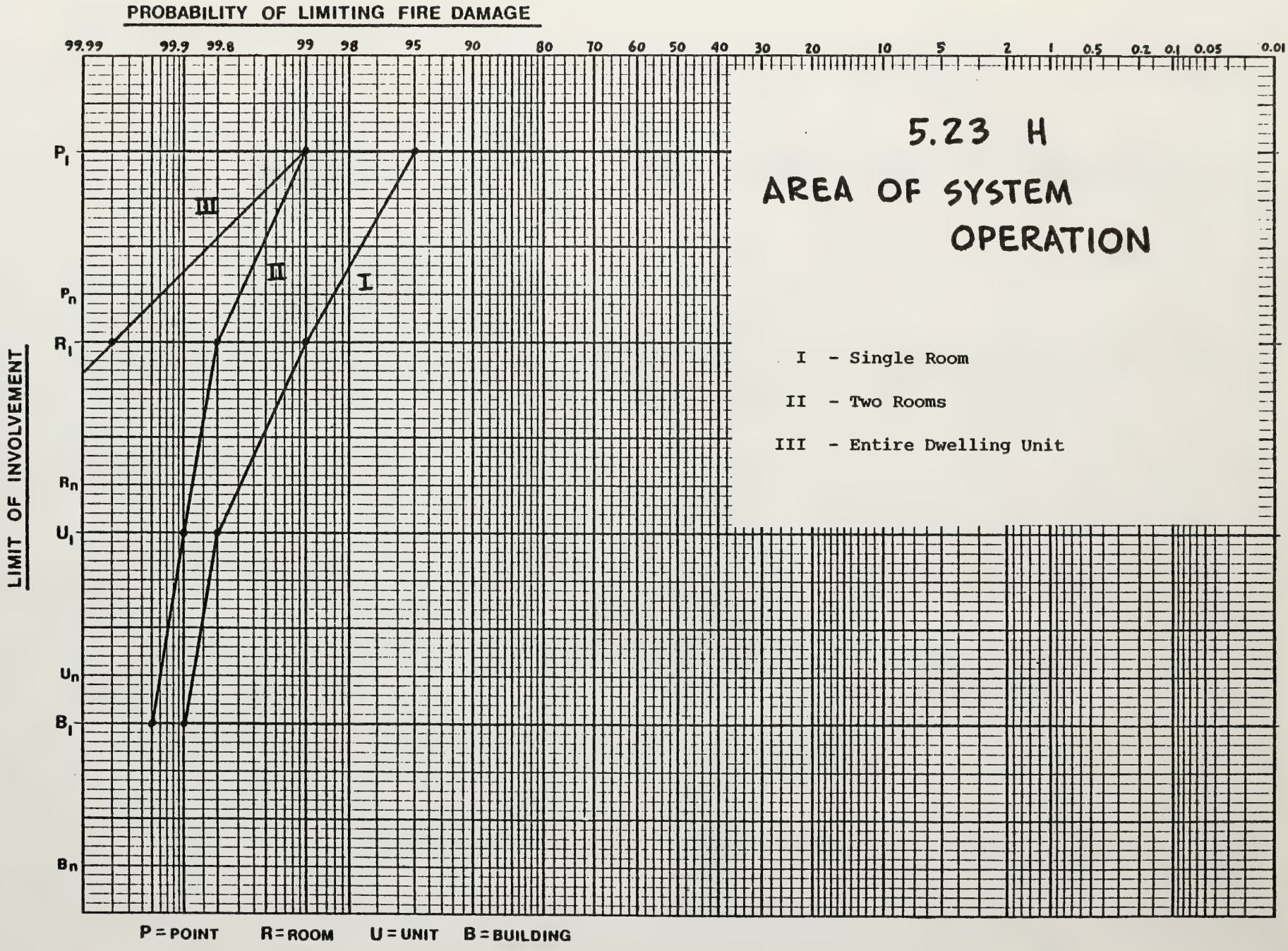
III-2.18 - Chart 5.22-H Agent Supply Duration

Chart 5.22-H is identical to Chart 5.22-CO2 and is based on judgment of Class "A" fire tests of halon system effectiveness.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
II
I
5.22 H
AGENT SUPPLY DURATION
I - 5 Minute Soaking Time
II - 10 Minute Soaking Time
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.19 - Chart 5.23-H Area of System Operation

Chart 5.23-H is identical to Chart 5.23-HXF.



5.23 H

AREA OF SYSTEM OPERATION

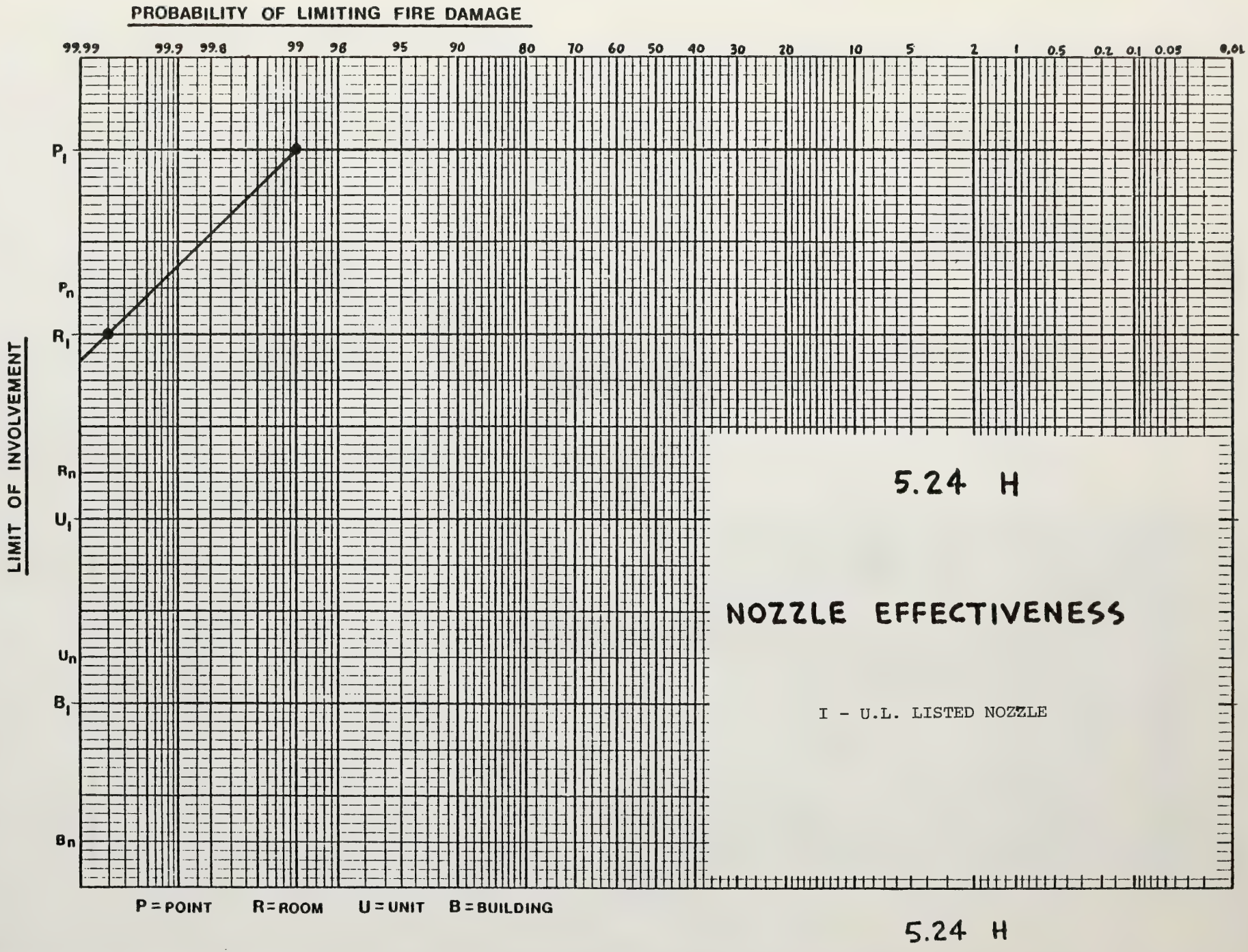
I - Single Room

II - Two Rooms

III - Entire Dwelling Unit

III-2.20 - Chart 5.24-H Nozzle Effectiveness

Chart 5.24-H is identical to Chart 5.24 HFX.

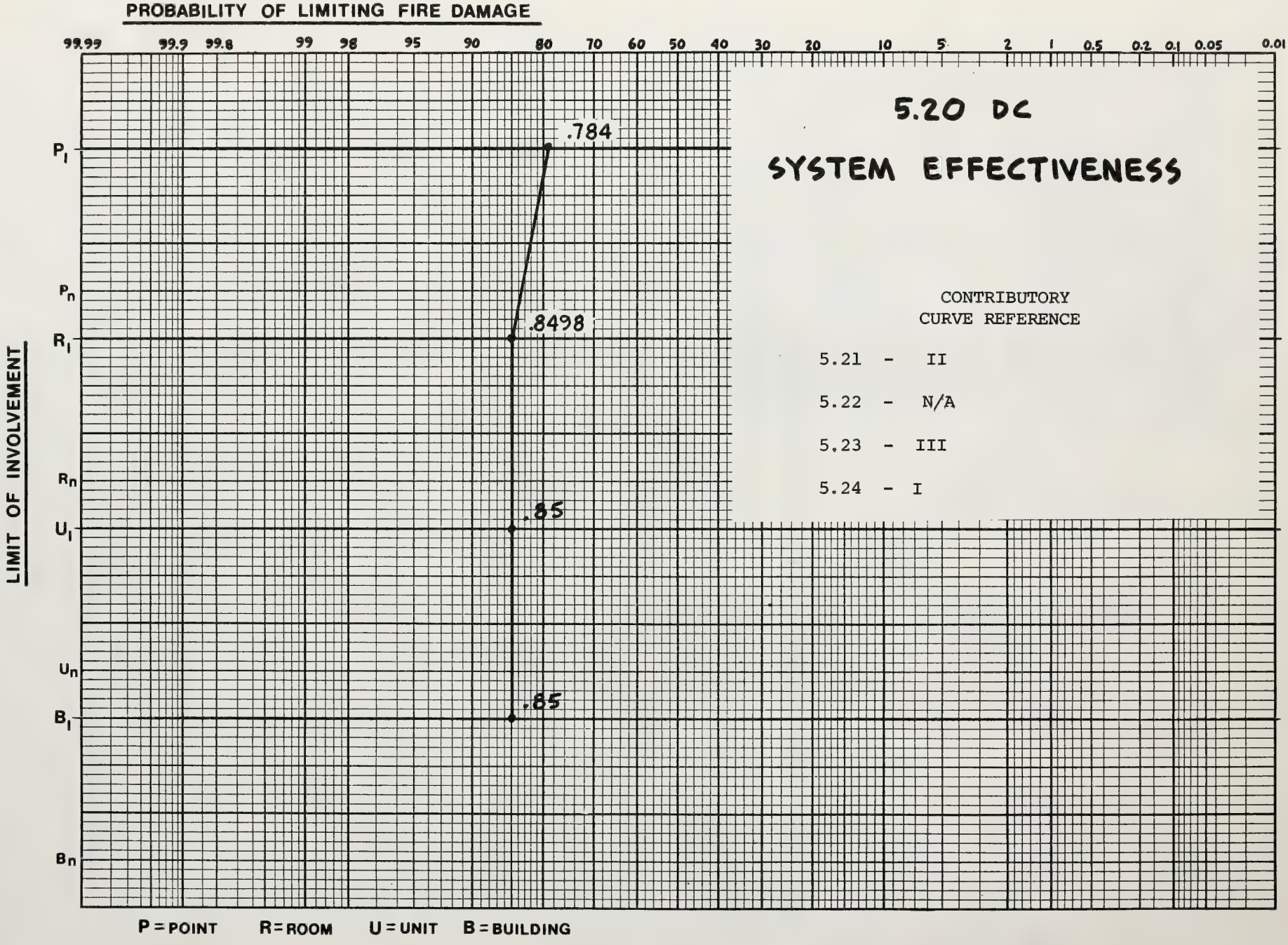

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
5.24 H
NOZZLE EFFECTIVENESS
I - U.L. LISTED NOZZLE

5.24 H

III-2.21 - Chart 5.20-DC System Effectiveness

III-2.21.1 Chart 5.20-DC shows the effectiveness of a multi-purpose dry chemical system in limiting fire damage. The dry chemical system is comparable to the carbon dioxide system in controlling fire damage.

III-2.21.2 The curve on Chart 5.20 DC was developed in the same fashion as the previously discussed curves on Chart 5.20 AS.

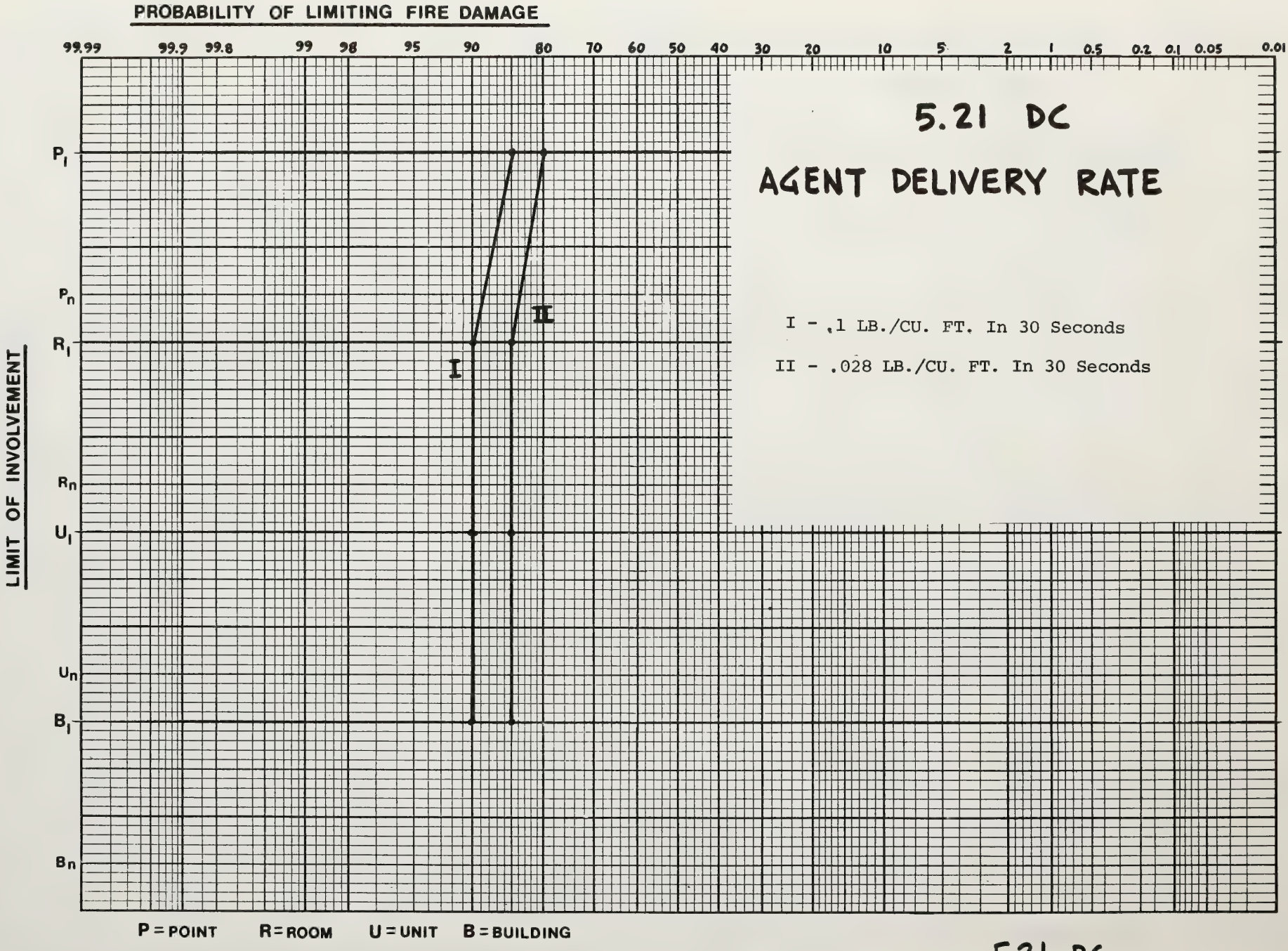

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.784
.8498
.85
.85
5.20 DC
SYSTEM EFFECTIVENESS
CONTRIBUTORY
CURVE REFERENCE
5.21 - II
5.22 - N/A
5.23 - III
5.24 - I
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.22 - Chart 5.21-DC Agent Delivery Rate

III-2.22.1 Chart 5.21-DC shows the effectiveness of the agent delivery rate in controlling fire damage.

III-2.22.2 A minimum delivery rate of 0.028 lbs. per cubic ft. delivered within 30 seconds of system actuation is considered acceptable (MAPL).

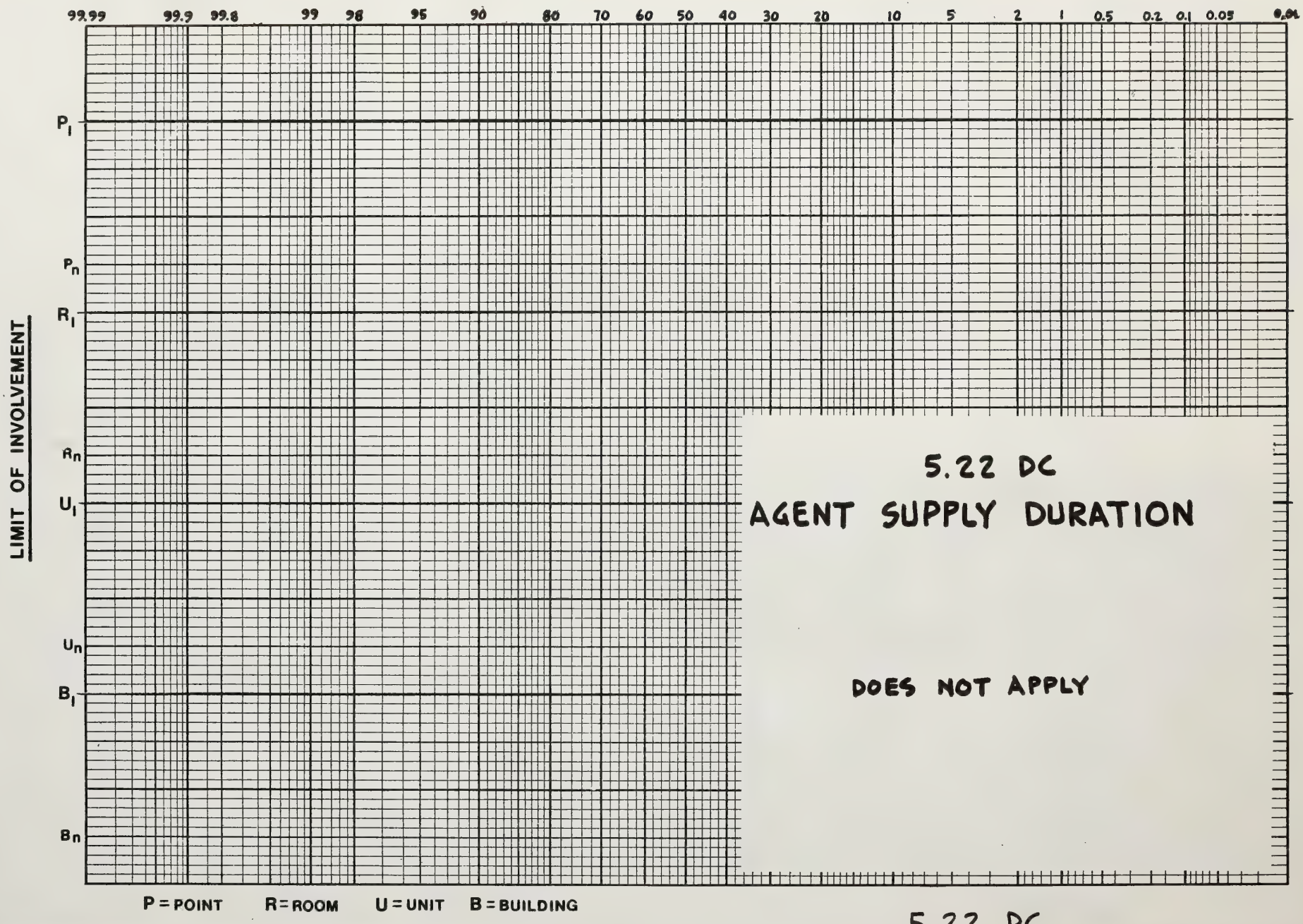
III-2.22.3 The curves are based on evaluation of published data (UL Listings) of multi-purpose dry chemical systems' ability to extinguish Class "A" fire.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
5.21 DC
AGENT DELIVERY RATE
I - .1 LB./CU. FT. In 30 Seconds
II - .028 LB./CU. FT. In 30 Seconds
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.21 DC

III-2.23 - Chart 5.22-DC Agent Supply Duration

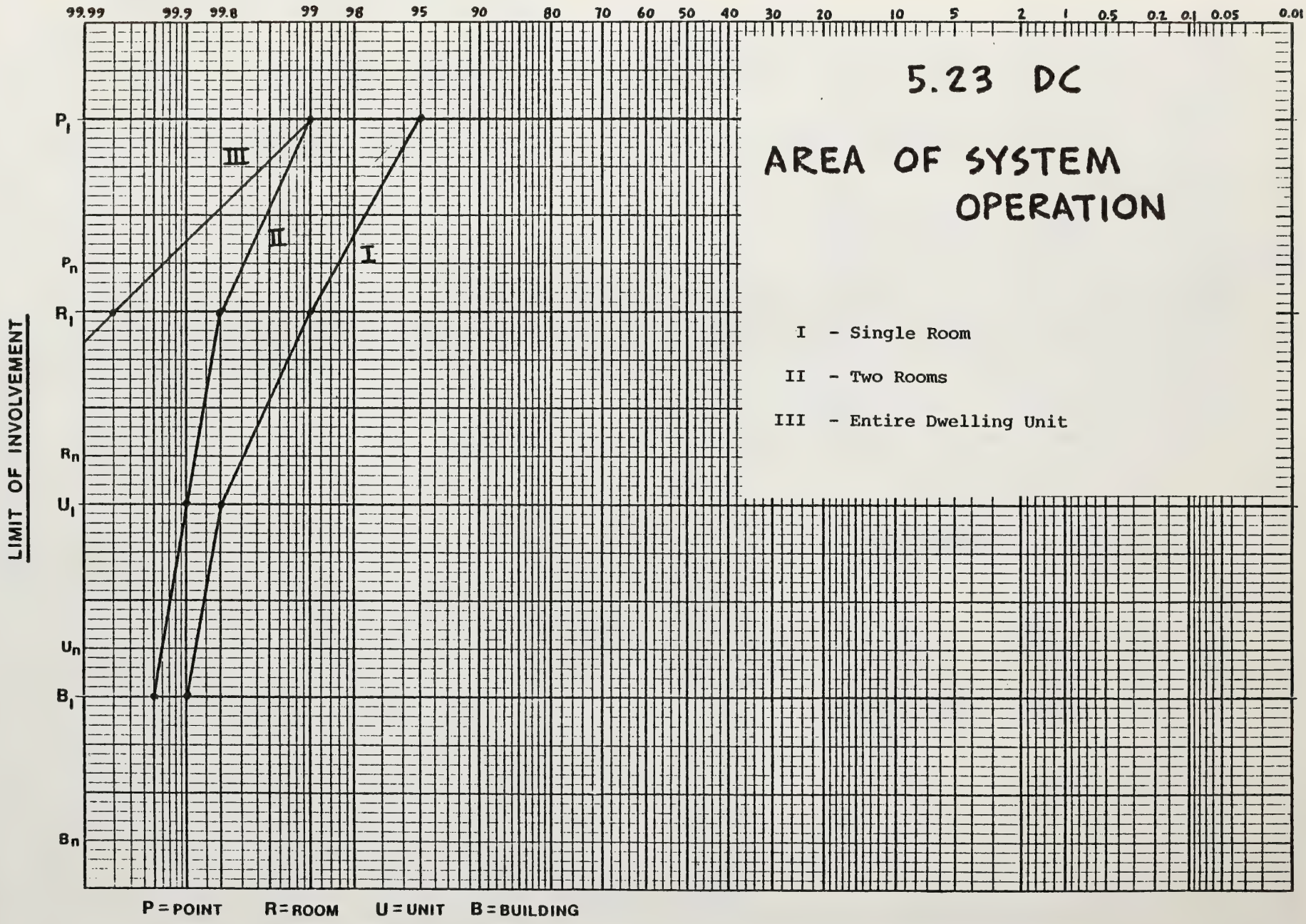
Chart 5.22-DC does not apply since the variable of supply duration is accounted for in Chart 5.21-DC.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
5.22 DC
AGENT SUPPLY DURATION
DOES NOT APPLY

5.22 DC

III-2.24 - Chart 5.23-DC Area of System Operation

Chart 5.23-DC is identical to Chart 5.23-HXF.



5.23 DC

AREA OF SYSTEM OPERATION

I - Single Room

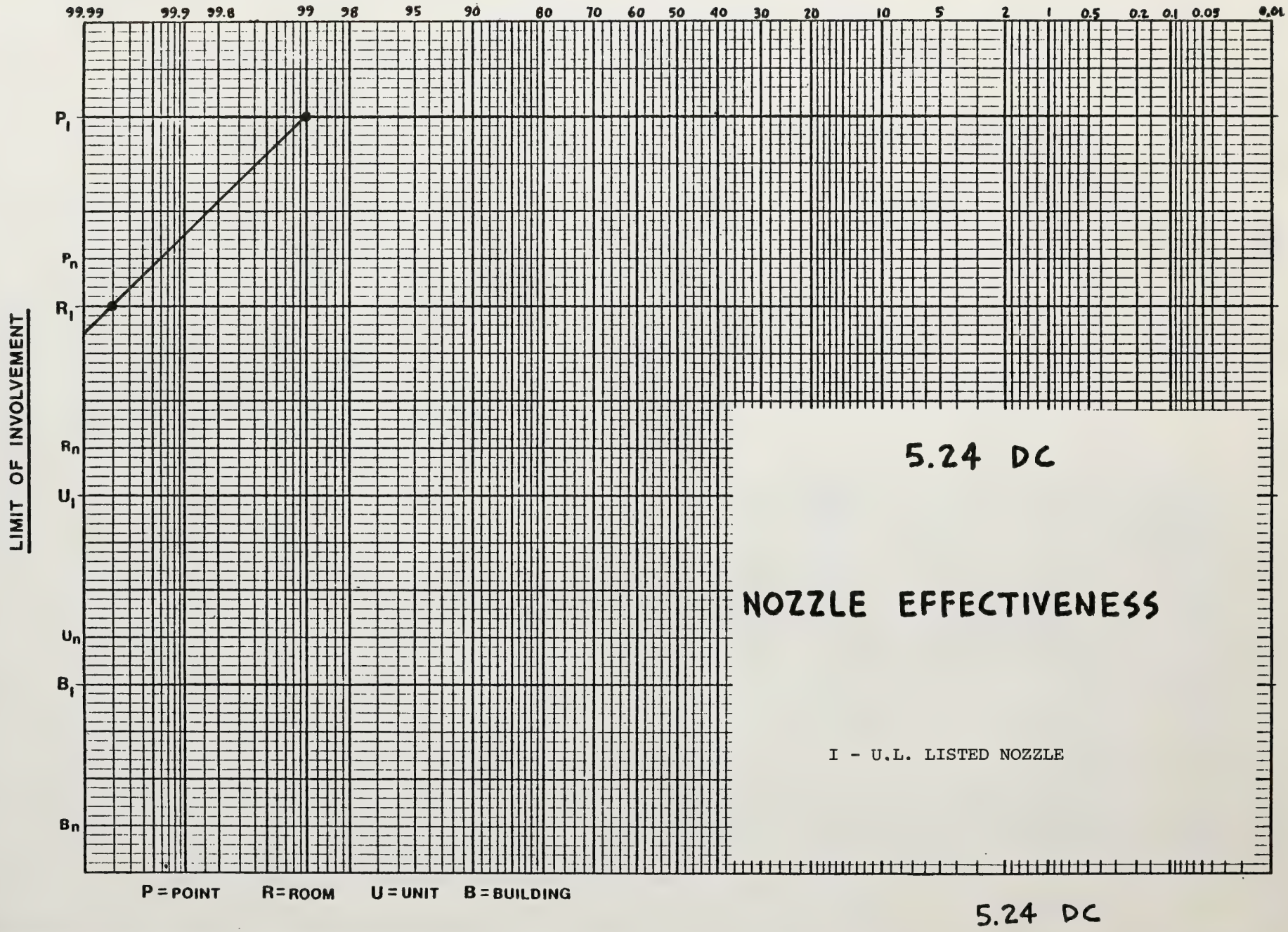
II - Two Rooms

III - Entire Dwelling Unit

5.23 DC

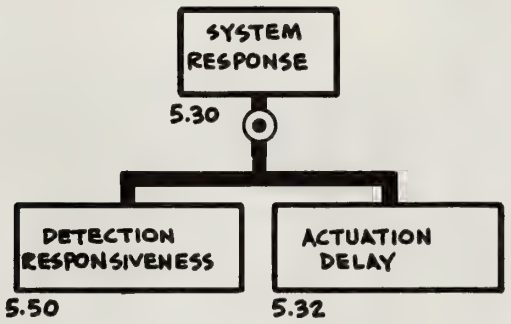
III-2.25 - Chart 5.24 - DC-Nozzle Effectiveness

Chart 5.24-DC is identical to Chart 5.24 HXF.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
5.24 DC
NOZZLE EFFECTIVENESS
I - U.L. LISTED NOZZLE
5.24 DC

III-2.26 - Chart 5.30-AS System Response

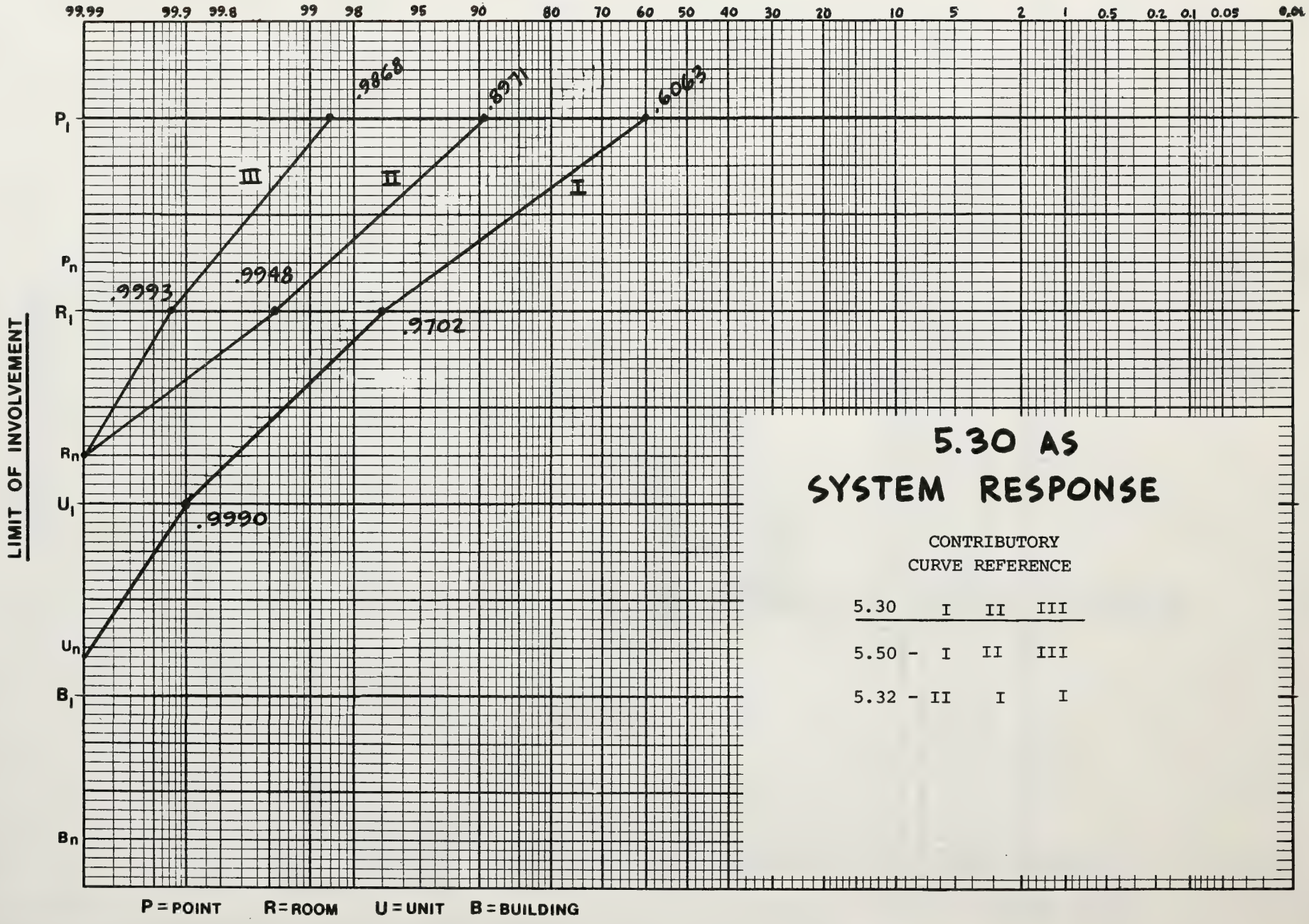
III-2.26.1 Chart 5.30-AS shows the ability of an automatic suppression system to respond to a fire in sufficient time to limit fire damage. The chart considers the effects of the system actuation delay and the responsiveness of the fire detection elements using an "AND" gate since both are necessary for the system to respond to fire.



III-2.26.2 The system described by Curve I is a Level I system.

III-2.26.3 The system described by Curve II is a Level II system.

III-2.26.4 The system described by Curve III is a Level III system.



5.30 AS
SYSTEM RESPONSE

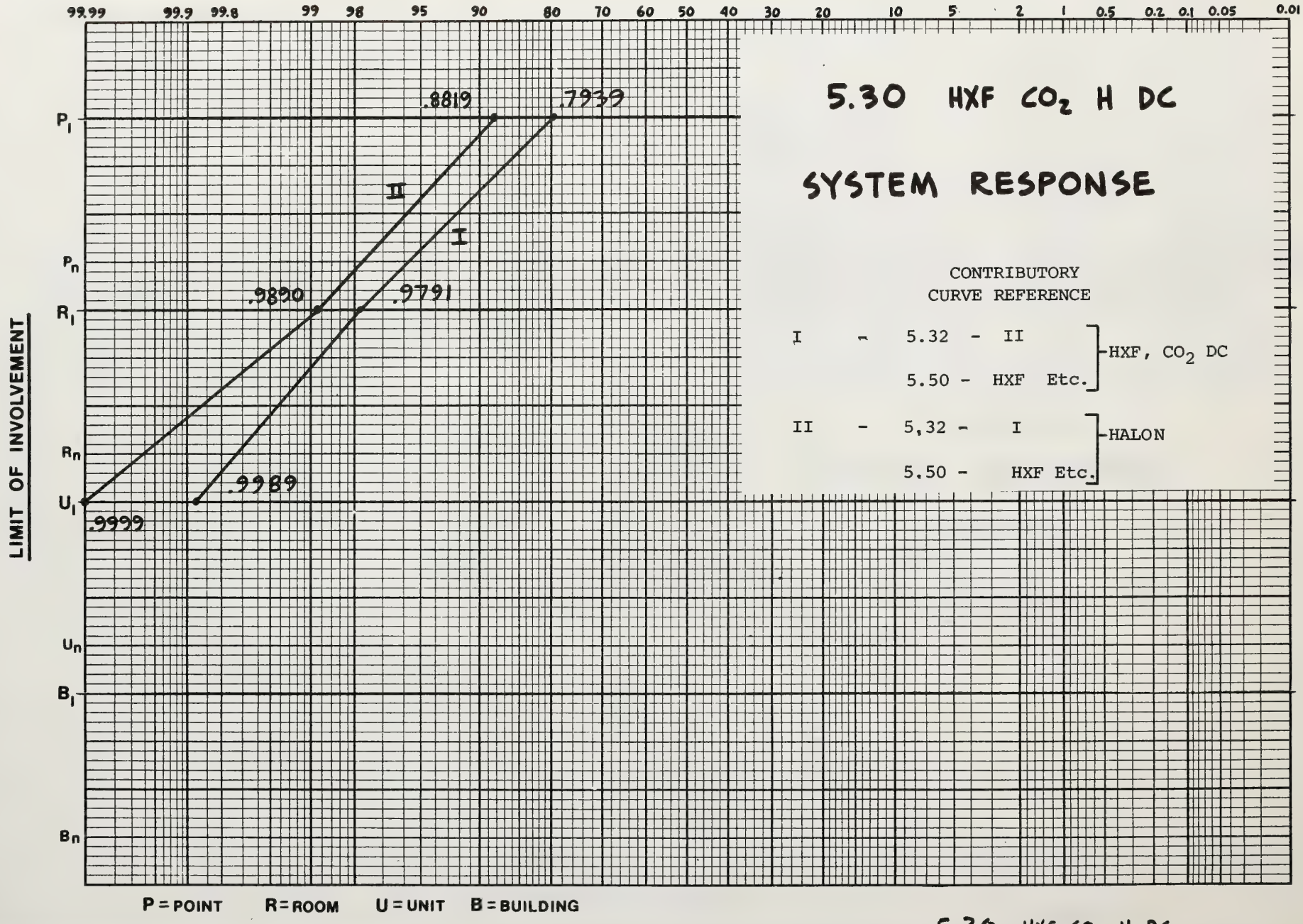
CONTRIBUTORY
CURVE REFERENCE

5.30	I	II	III
5.50 -	I	II	III
5.32 -	II	I	I

III-2.27 - Chart 5.30-HXF, CO2, H, DC System Response

III-2.27.1 Chart 5.30-HXF, CO2, H, DC shows the effectiveness of the response elements for high expansion foam, carbon dioxide, halon and dry chemical systems. The response for these systems is somewhat better for smaller fires than the response for sprinkler systems expressed on Chart 5.30-AS because these systems use a "smoke" sensitive detection/actuation mechanism.

III-2.27.2 Curve I represents HXF, CO2 and DC systems while Curve II represents Halon systems.



5.30 HXF CO_2 H DC

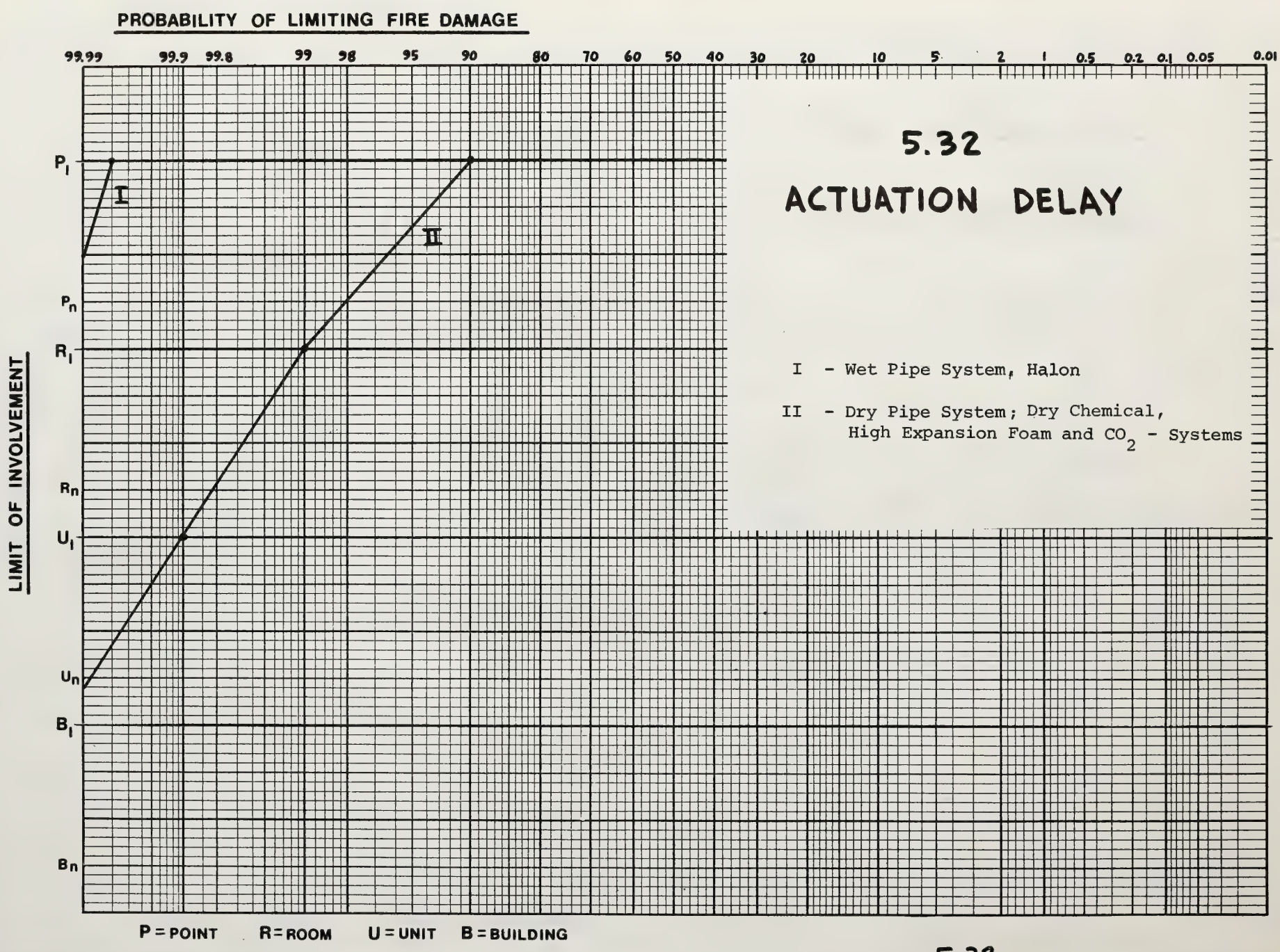
III-2.28 - Chart 5.32 - Actuation Delay

III-2.28.1 Chart 5.32 shows the effect of actuation delay on the fire damage extent.

III-2.28.2 The actuation delay of a wet pipe sprinkler system and a halon system is negligible.

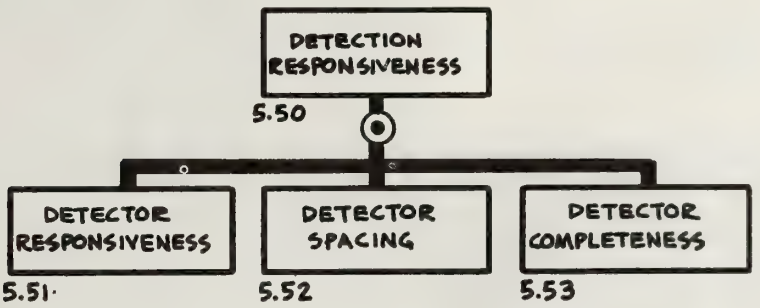
III-2.28.3 The actuation delay of high expansion foam, carbon dioxide, and dry chemical systems is considered to be comparable to a dry pipe sprinkler system because of the need for a pre-discharge evacuation delay and occupant warning alarm.

III-2.28.4 The curves are based on judgment of dry pipe sprinkler and other system performance records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
5.32
ACTUATION DELAY
I - Wet Pipe System, Halon
II - Dry Pipe System; Dry Chemical, High Expansion Foam and CO2 - Systems
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.29 - Chart 5.50-AS Detection Responsiveness

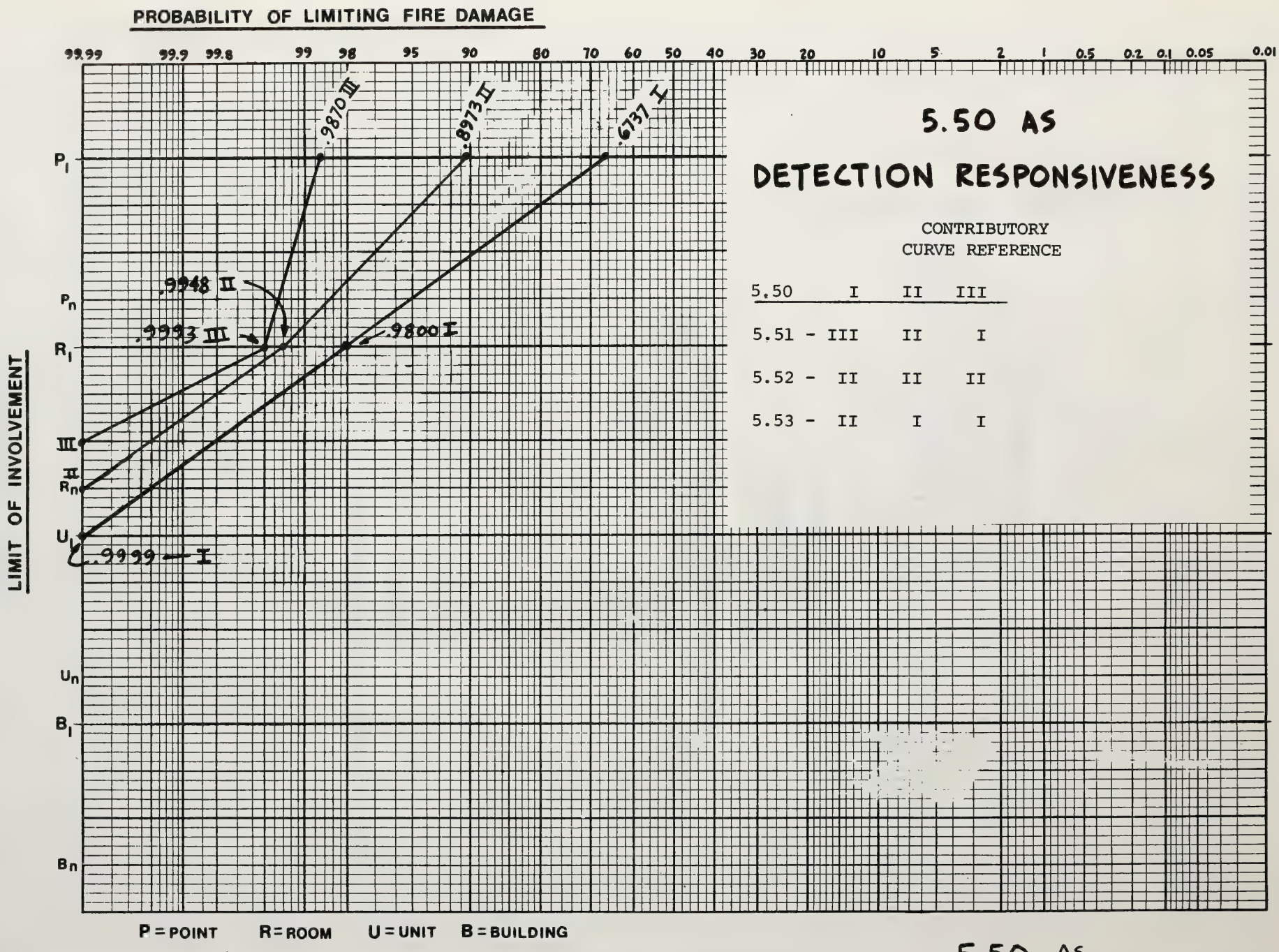
III-2.29.1 Chart 5.50-AS shows the ability of the detection system to respond to fire. The curves are the product of detector responsiveness, detector spacing and detector completeness combined through an "AND" gate since all are necessary for fire detection.



III-2.29.2 Curve I represents a Level I system.

III-2.29.3 Curve II represents a Level II system.

III-2.29.4 Curve III represents a Level III system.

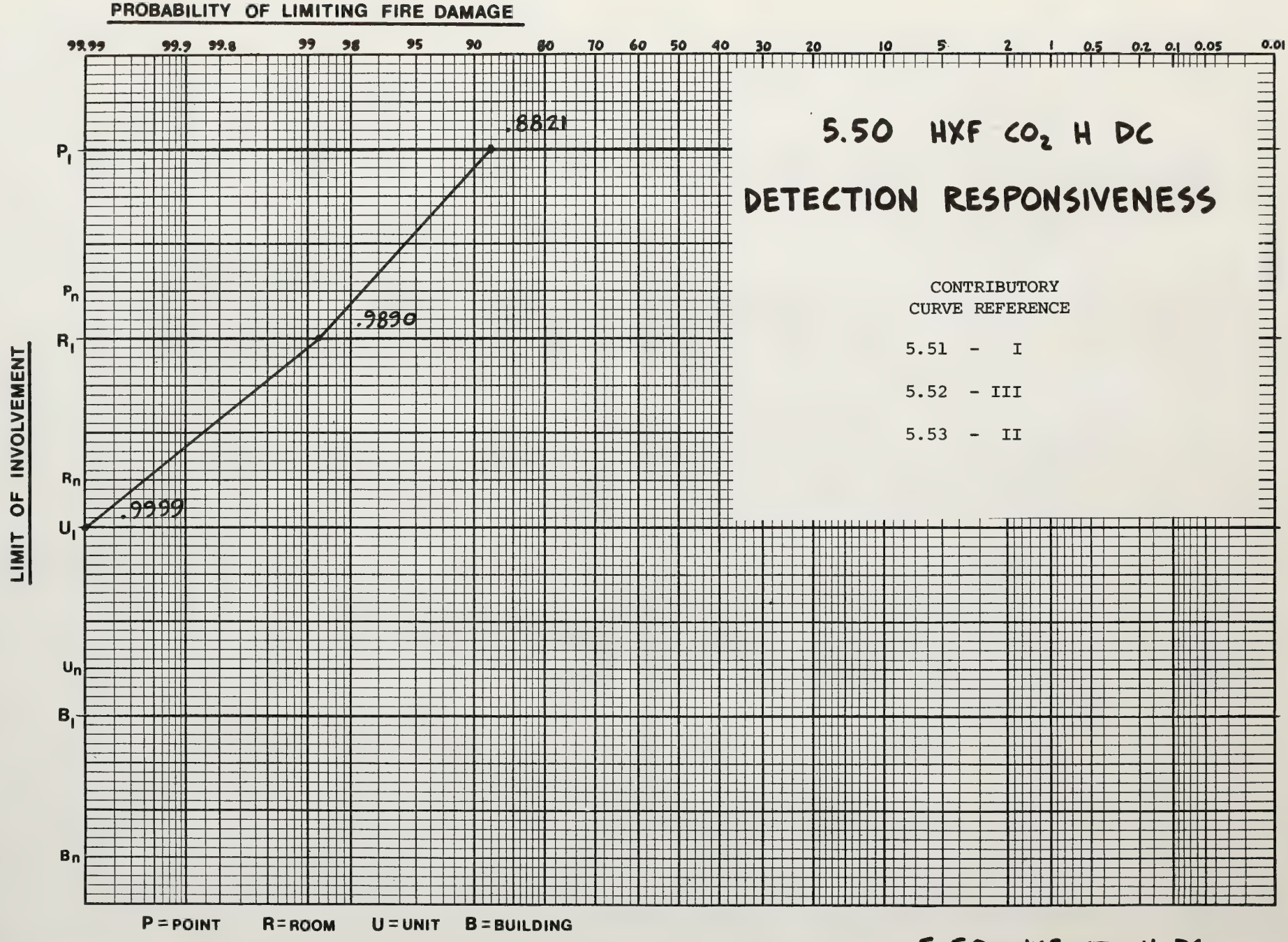

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9870 III
.8973 II
.6737 I
.9948 II
.9993 III
.9800 I
.9999 — I
5.50 AS
DETECTION RESPONSIVENESS
CONTRIBUTORY
CURVE REFERENCE
5.50 I II III
5.51 - III II I
5.52 - II II II
5.53 - II I I
P = POINT R = ROOM U = UNIT B = BUILDING

5.50 AS

III-2.30 - Chart 5.50-HXF, CO2, H, DC Detection Responsiveness

III-2.30.1 Chart 5.50-HXF, CO2, H, DC shows the responsiveness of the detection systems for the referenced systems.

III-2.30.2 The curve on this chart was developed in the same fashion as the curve on Chart 5.50 AS.



5.50 HXF CO_2 H DC

III-2.31 - Chart 5.51 - Detector Responsiveness

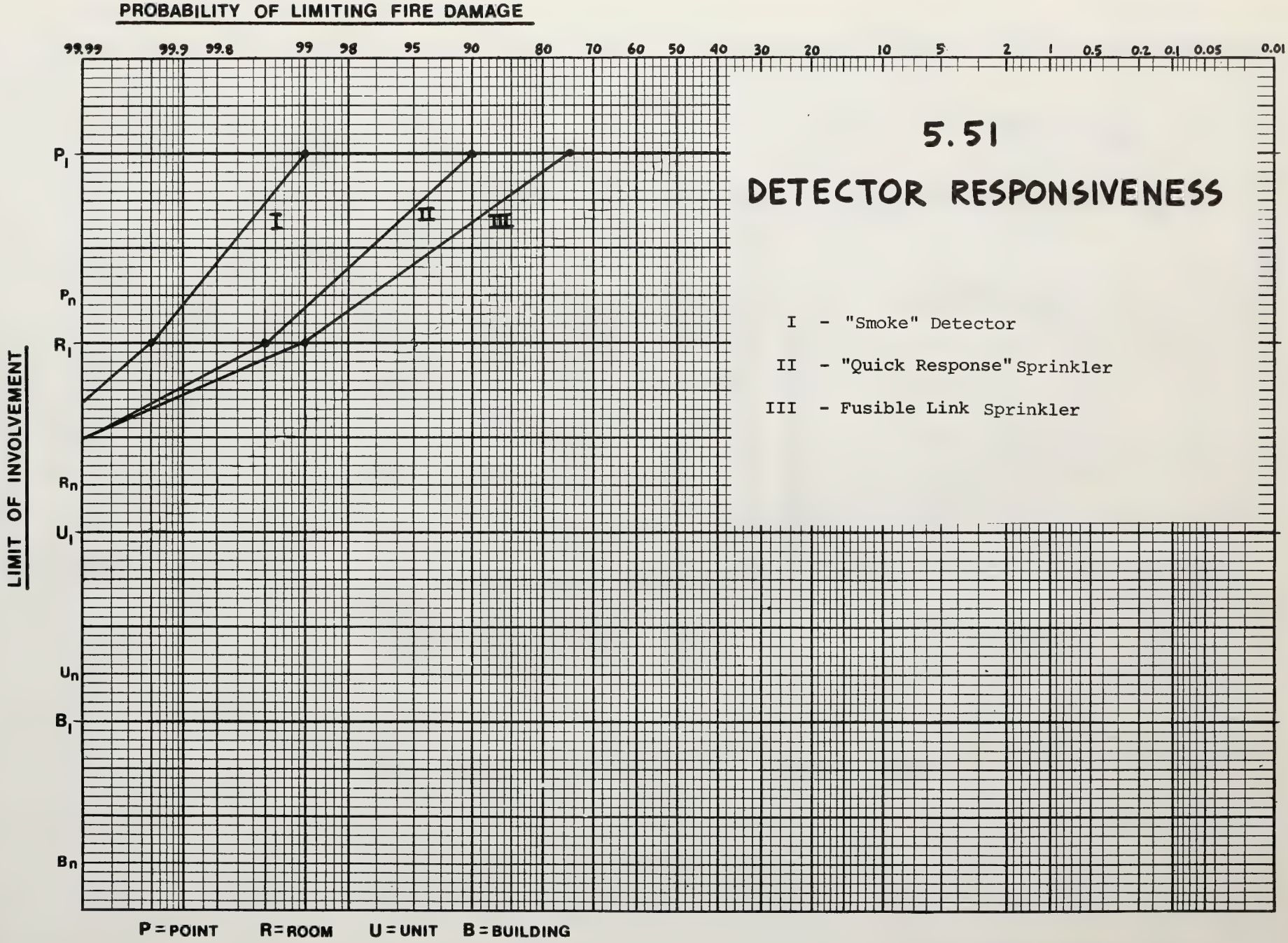
III-2.31.1 Chart 5.51 shows the effect of three types of detectors in limiting the extent of fire damage.

III-2.31.2 The fusible link sprinkler is considered an acceptable type of detection device for a residential sprinkler system (MAPL).

III-2.31.3 The "smoke" detector is considered as being acceptable for operation of the high expansion foam, carbon dioxide, halon and dry chemical systems (MAPL).

III-2.31.4 A detection/actuation mechanism for a sprinkler system which is as dependable as the sprinkler head and as sensitive as a "smoke" detector has yet to be developed.

III-2.31.5 The curves are based on judgment considering fire research data regarding rate of fire development and fire records regarding the origin of residential fire.

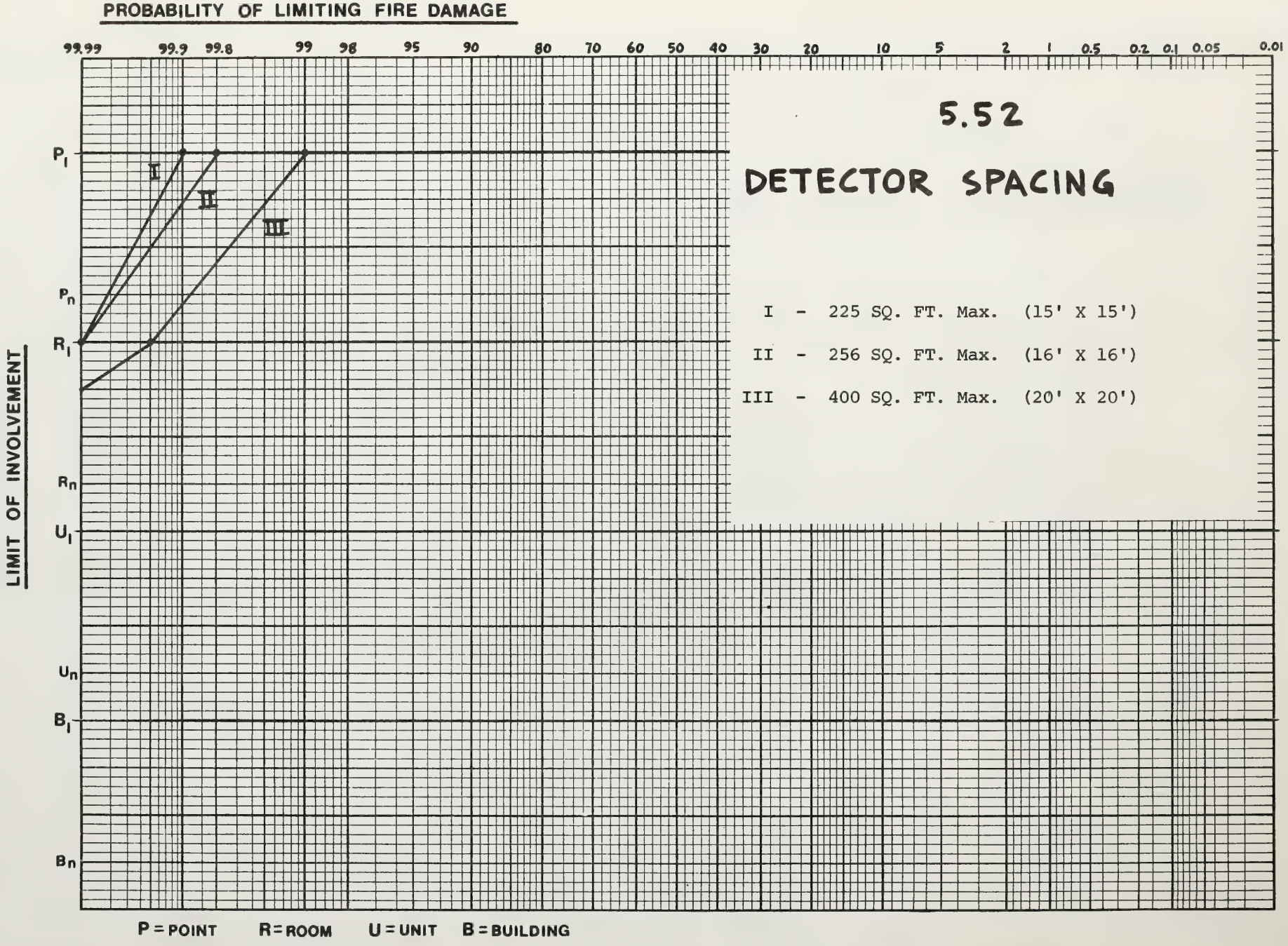

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
II
III
5.51
DETECTOR RESPONSIVENESS
I - "Smoke" Detector
II - "Quick Response" Sprinkler
III - Fusible Link Sprinkler
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.32 - Chart 5.52 - Detector Spacing

III-2.32.1 Chart 5.52 shows the effect of varying detector spacing on the extent of fire damage.

III-2.32.2 The maximum acceptable spacing for a sprinkler is 256 sq. ft. (with a maximum dimension of 16 ft.) The maximum acceptable spacing for "smoke" detectors is 400 sq. ft. (with a maximum dimension of 20 ft.)

III-2.32.3 The curves are based on judgment, considering the UL detector listing test methods (86, 87, 88) and fire research data.

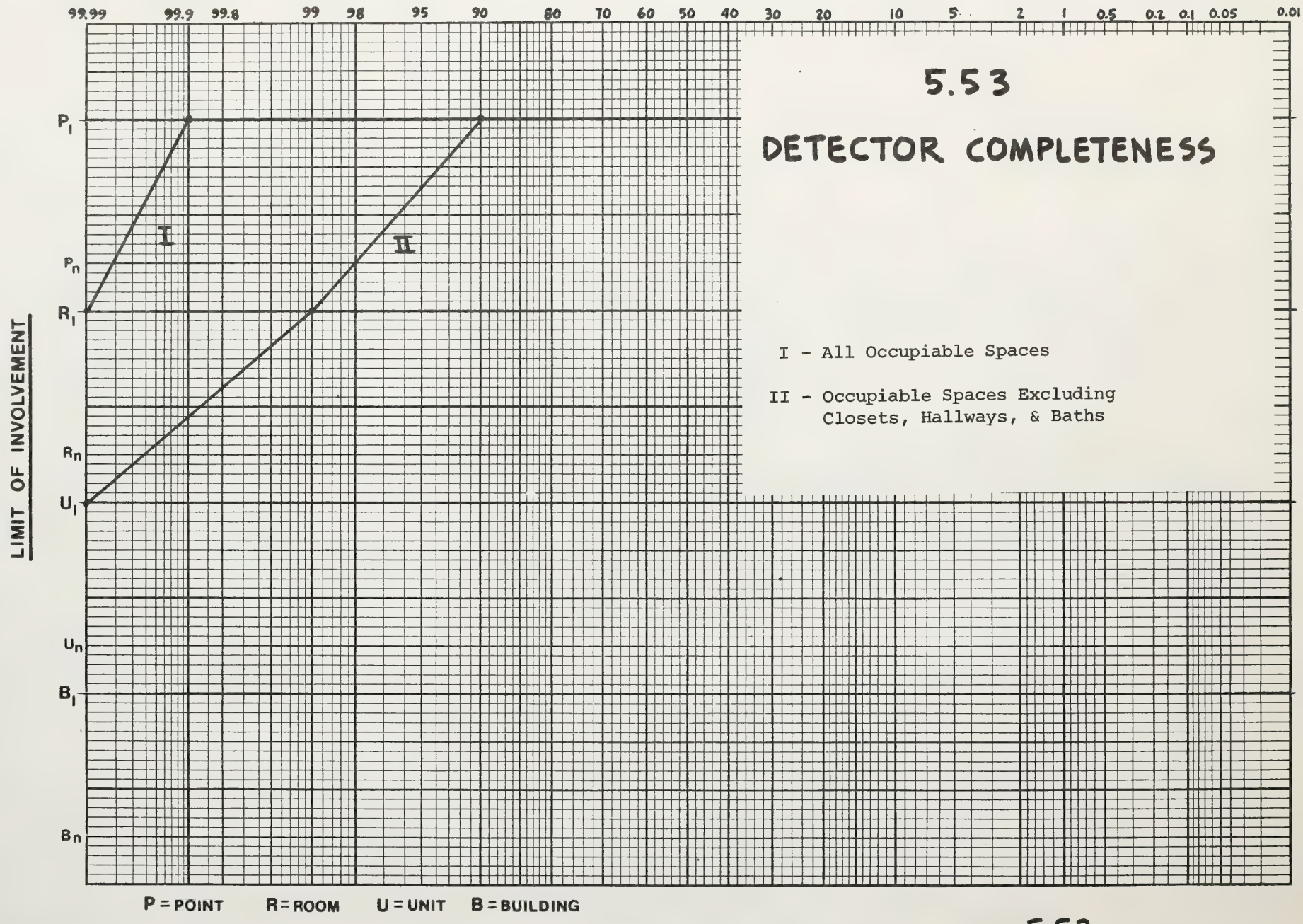

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
II
III
5.52
DETECTOR SPACING
I - 225 SQ. FT. Max. (15' X 15')
II - 256 SQ. FT. Max. (16' X 16')
III - 400 SQ. FT. Max. (20' X 20')
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.33 - Chart 5.53 - Detector Completeness

III-2.33.1 Chart 5.53 shows the effect of detector completeness in the residence on the extent of fire.

III-2.33.2 The minimum acceptable level of completeness includes all occupiable spaces except closets, hallways and baths (MAPL).

III-2.33.3 The curves are based on the NFPA records regarding location of residential fire origin (62).



5.53

DETECTOR COMPLETENESS

I - All Occupiable Spaces

II - Occupiable Spaces Excluding Closets, Hallways, & Baths

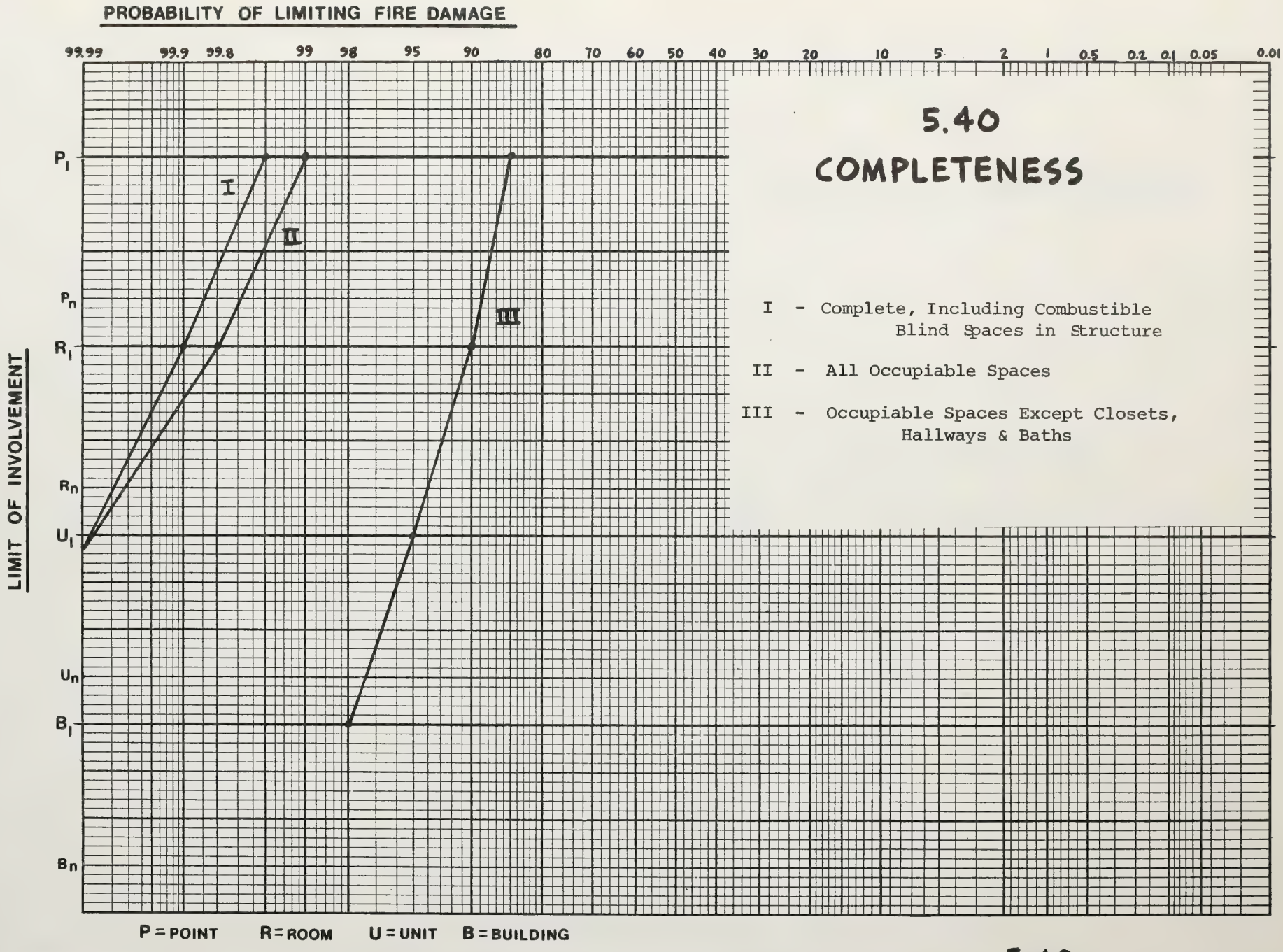
III-2.34 - Chart 5.40 - Completeness

III-2.34.1 Chart 5.40 shows the effect of completeness of the automatic suppression system in a residence on the fire damage extent.

III-2.34.2 .The minimum acceptable level of completeness includes of all occupiable spaces except closets, hallways and baths (MAPL).

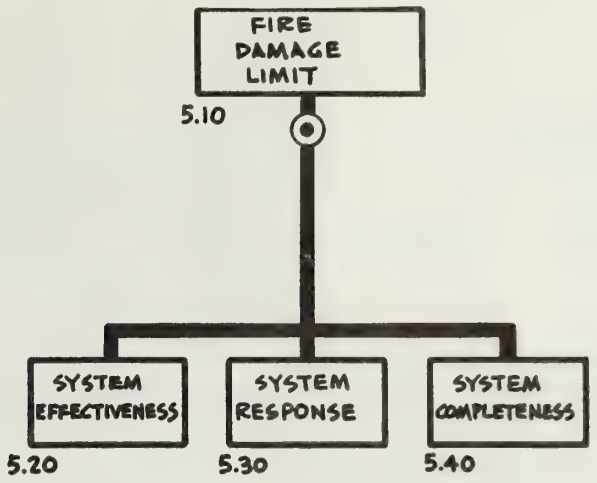
III-2.34.3 There is a marked improvement in the system ability to control fire if all occupiable spaces including closets, hallways and baths are protected.

III-2.34.4 The curves are based on NFPA records regarding location of residential fire (62).


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_l
P_n
R_l
R_n
U_l
U_n
B_l
B_n
I
II
III
5.40
COMPLETENESS
I - Complete, Including Combustible Blind Spaces in Structure
II - All Occupiable Spaces
III - Occupiable Spaces Except Closets, Hallways & Baths
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.35 - Chart 5.10 - AS Fire Damage Limit

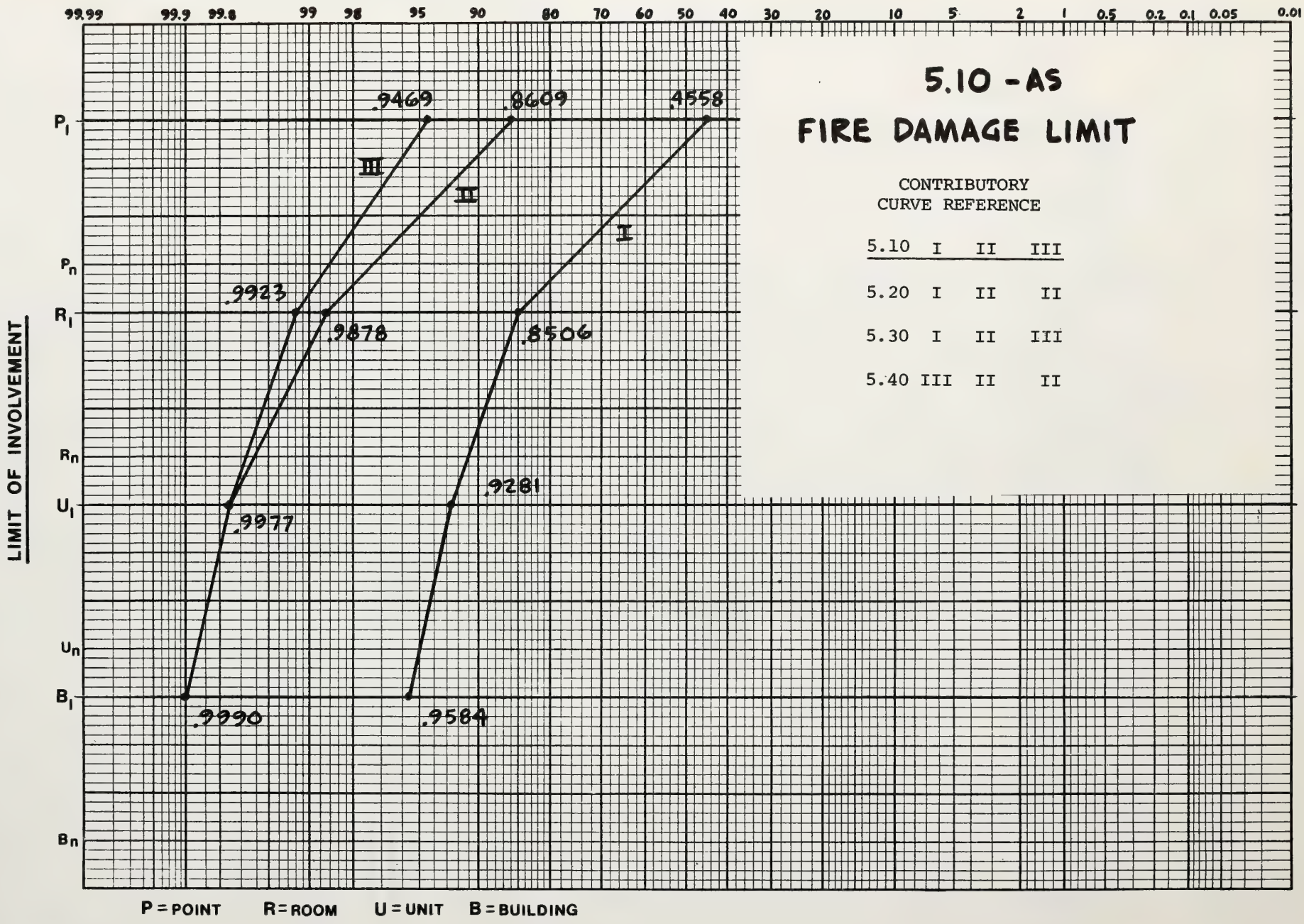
III-2.35.1 Chart 5.10 - AS shows the ability of the sprinkler system (defined by the contributory charts) to limit fire damage. The curves on this chart are the product of the curves of Charts 5.20, 5.30 and 5.40 combined through an "AND" gate since all are necessary to limit fire damage.



III-2.35.2 Curve I represents the Level I sprinkler system. This system is effective in controlling fire damage beyond the room of origin, but is somewhat less effective in controlling damage to within the room of origin.

III-2.35.3 Curve II represents the Level II system. This system is somewhat more effective than the Level I system in controlling fire damage within the room of origin and beyond.

III-2.35.4 Curve III represents the Level III system. This system is more capable in limiting damage to within the room of origin than the other systems and is comparable to the Level II system in preventing damage beyond the room of origin.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9469
.8609
.4558
.9923
.9878
.8506
.9977
.9281
.9990
.9584
III
II
I
5.10 - AS
FIRE DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
5.10 I II III
5.20 I II II
5.30 I II III
5.40 III II II
P = POINT
R = ROOM
U = UNIT
B = BUILDING

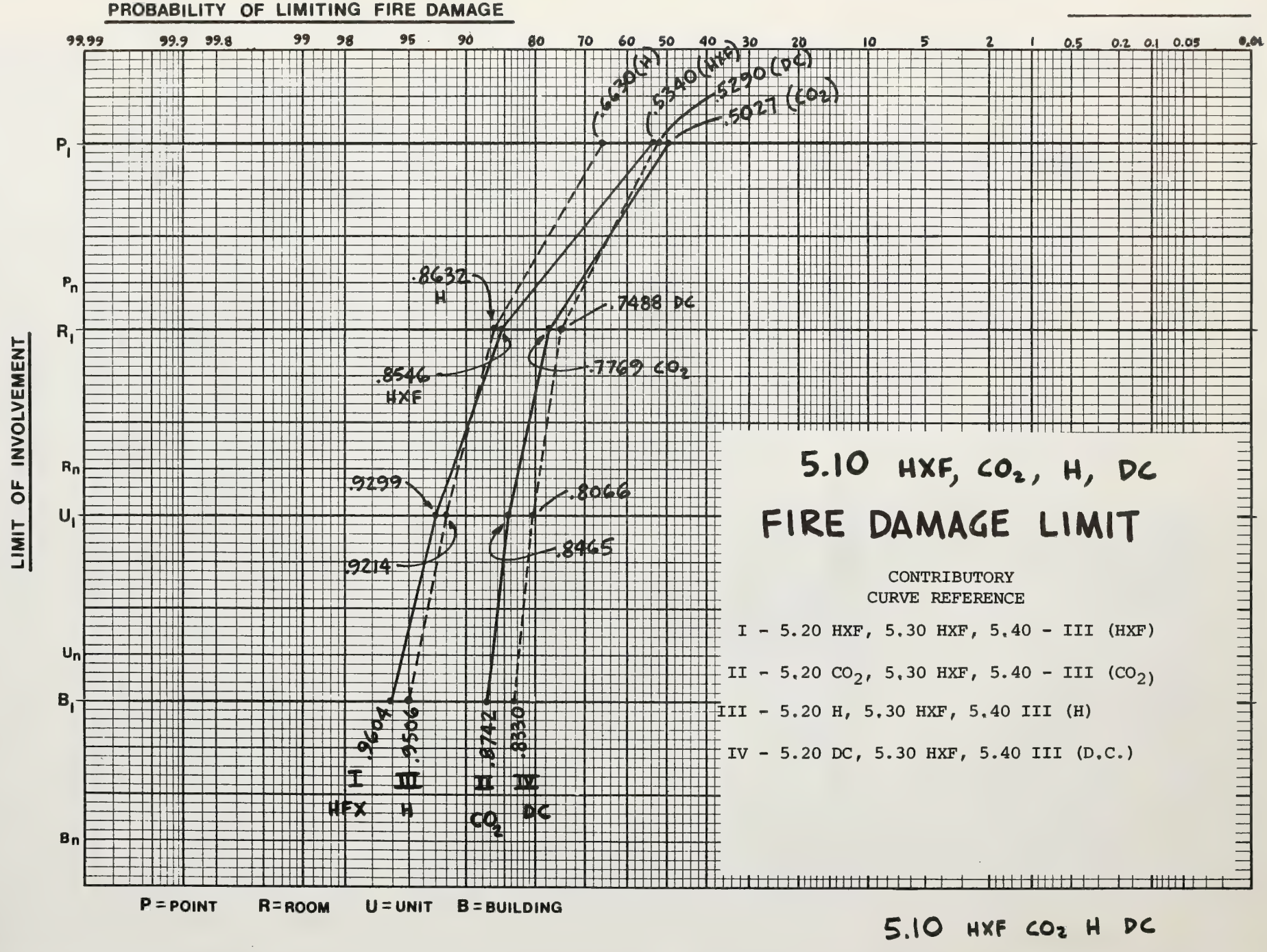
III-2.36 - Chart 5.10-HFX, CO2, H, DC Fire Damage Limit

III-2.36.1 The curves on this chart are an expression of the ability of the four referenced systems (defined by the contributory charts) to limit fire damage. The curves were developed in the same fashion as the curves on Chart 5.10 AS.

III-2.36.2 These systems are somewhat more effective in limiting damage at the point of origin than the sprinkler system because of the improved responsiveness of the "smoke" detector.

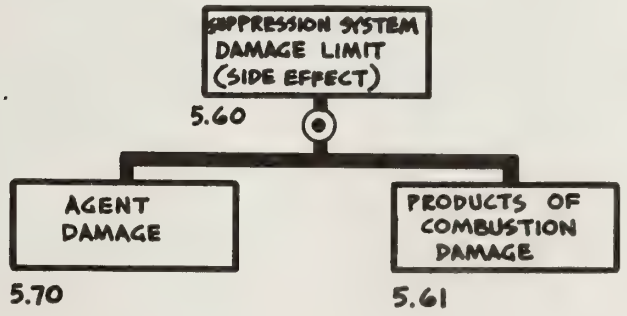
III-2.36.3 The halon and the high expansion foam systems are superior to the sprinkler systems in terms of their ability to limit fire damage beyond the room of origin.

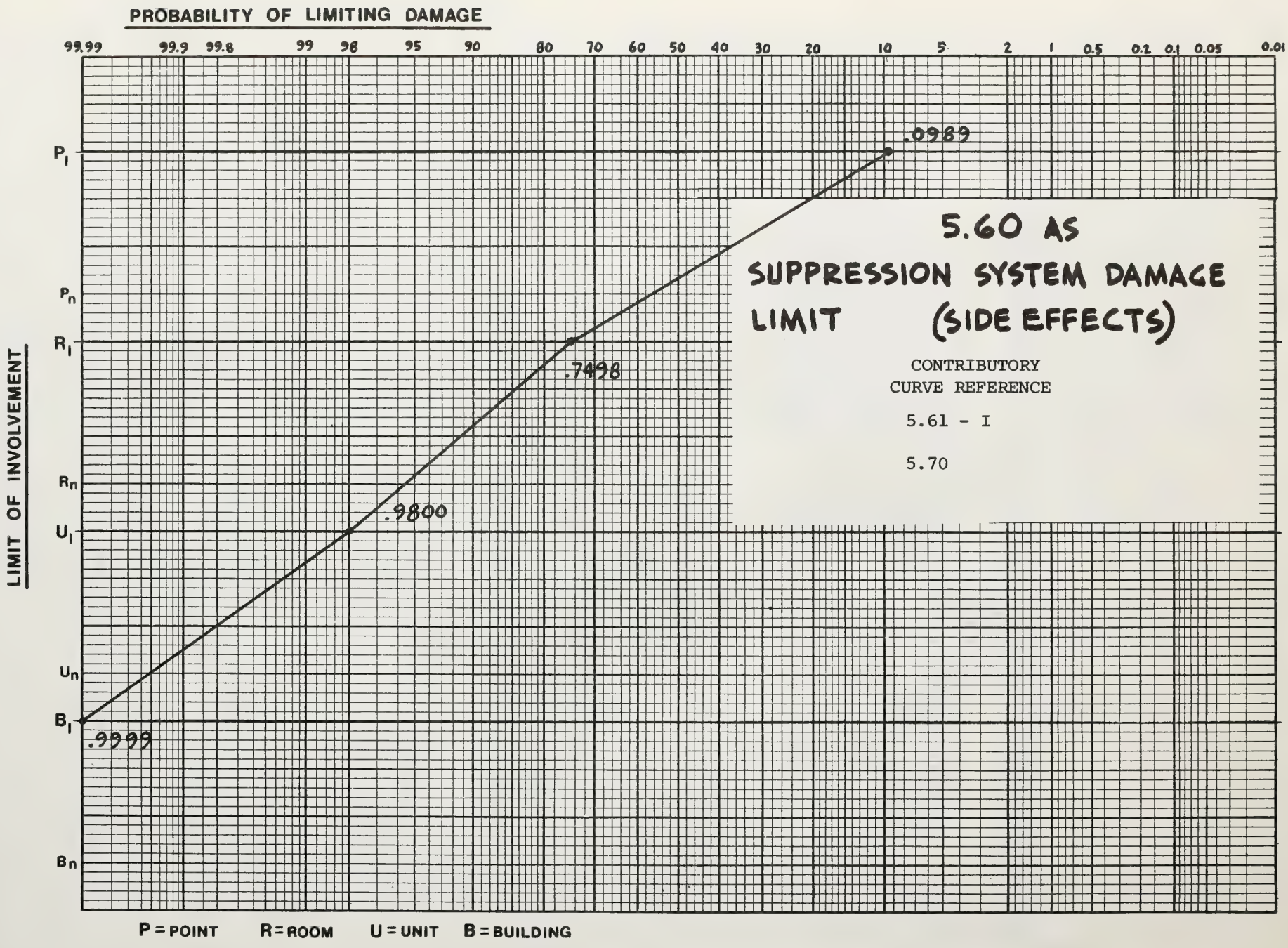
III-2.36.4 The sprinkler systems are comparable to the carbon dioxide and dry chemical systems in their ability to limit fire damage to the room of origin, but better in terms of their ability to limit fire damage beyond the room of origin.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.6630 (H)
.5340 (HXF)
.5290 (DC)
.5027 (CO2)
.8632 H
.7488 DC
.8546 HXF
.7769 CO2
.9299
.8066
.9214
.8465
.9604
.9506
.8742
.8330
I HFX
III H
II CO2
IV DC
5.10 HXF, CO2, H, DC
FIRE DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
I - 5.20 HXF, 5.30 HXF, 5.40 - III (HXF)
II - 5.20 CO2, 5.30 HXF, 5.40 - III (CO2)
III - 5.20 H, 5.30 HXF, 5.40 III (H)
IV - 5.20 DC, 5.30 HXF, 5.40 III (D.C.)
P = POINT R = ROOM U = UNIT B = BUILDING
5.10 HXF CO2 H DC

III-2.37 - Chart 5.60-AS Suppression System Damage Limit (Side Effects)

Chart 5.60-AS expresses the probability of damage caused by the automatic suppression system after it actuates, i.e. side effects. The chart is expressed in the same manner as the fire damage charts (probability of limiting damage is referenced to the point of origin, the room of origin, the unit of origin and the building of origin). The curve on Chart 5.60 is the product of the agent damage and the products of combustion damage combined through an "AND" gate as both will occur during the extinguishing process.

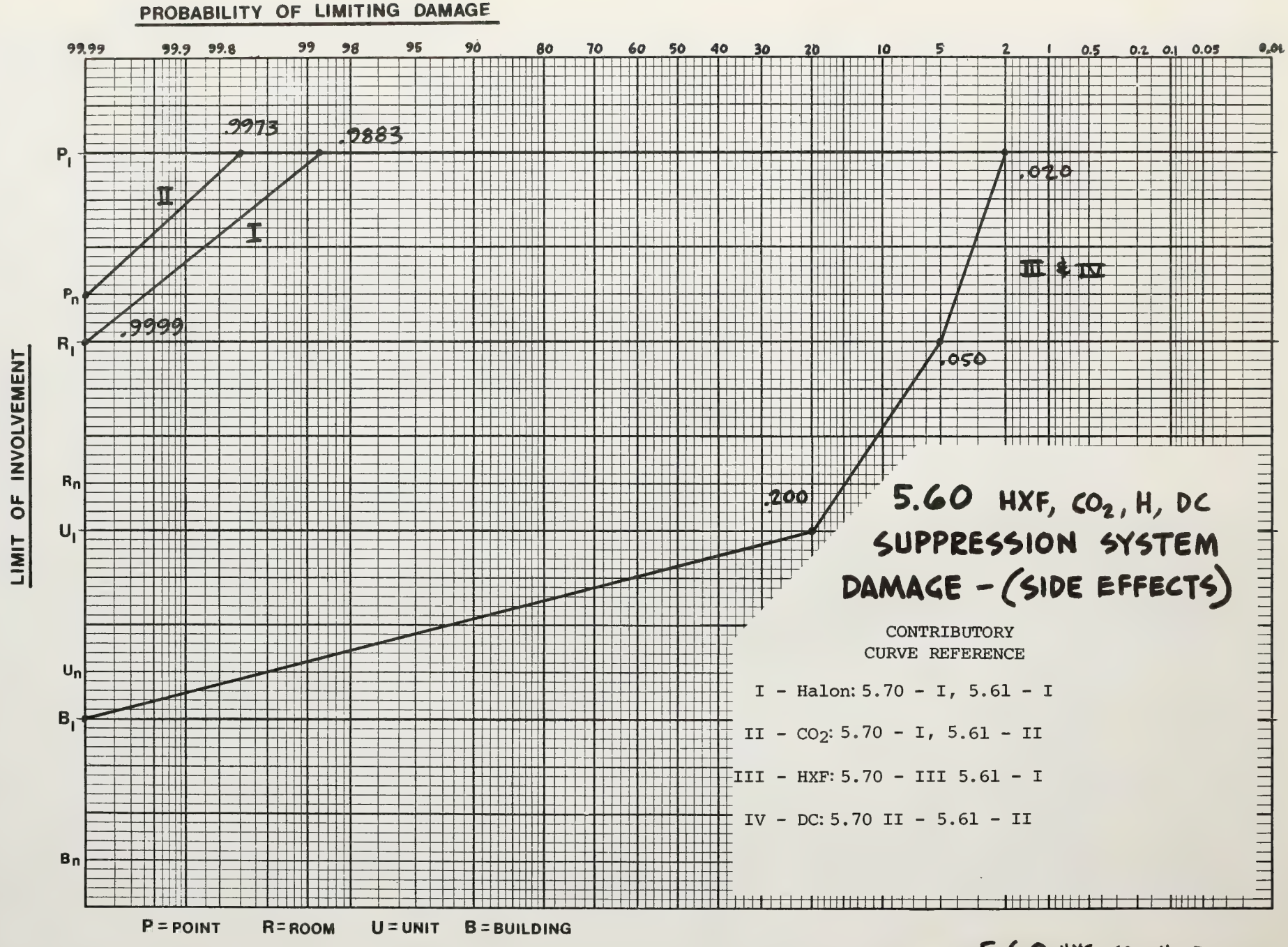



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0989
.7498
.9800
.9999
5.60 AS
SUPPRESSION SYSTEM DAMAGE LIMIT (SIDE EFFECTS)
CONTRIBUTORY CURVE REFERENCE
5.61 - I
5.70
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.60 AS

III-2.38 - Chart 5.60-HXF, CO2, H, DC Suppression System Damage (Side Effects)

Chart 5.60-HXF, CO2, H, DC expresses the side effects damage potential of the four referenced systems. The curves were developed in the same fashion as the curve on Chart 5.60 AS.

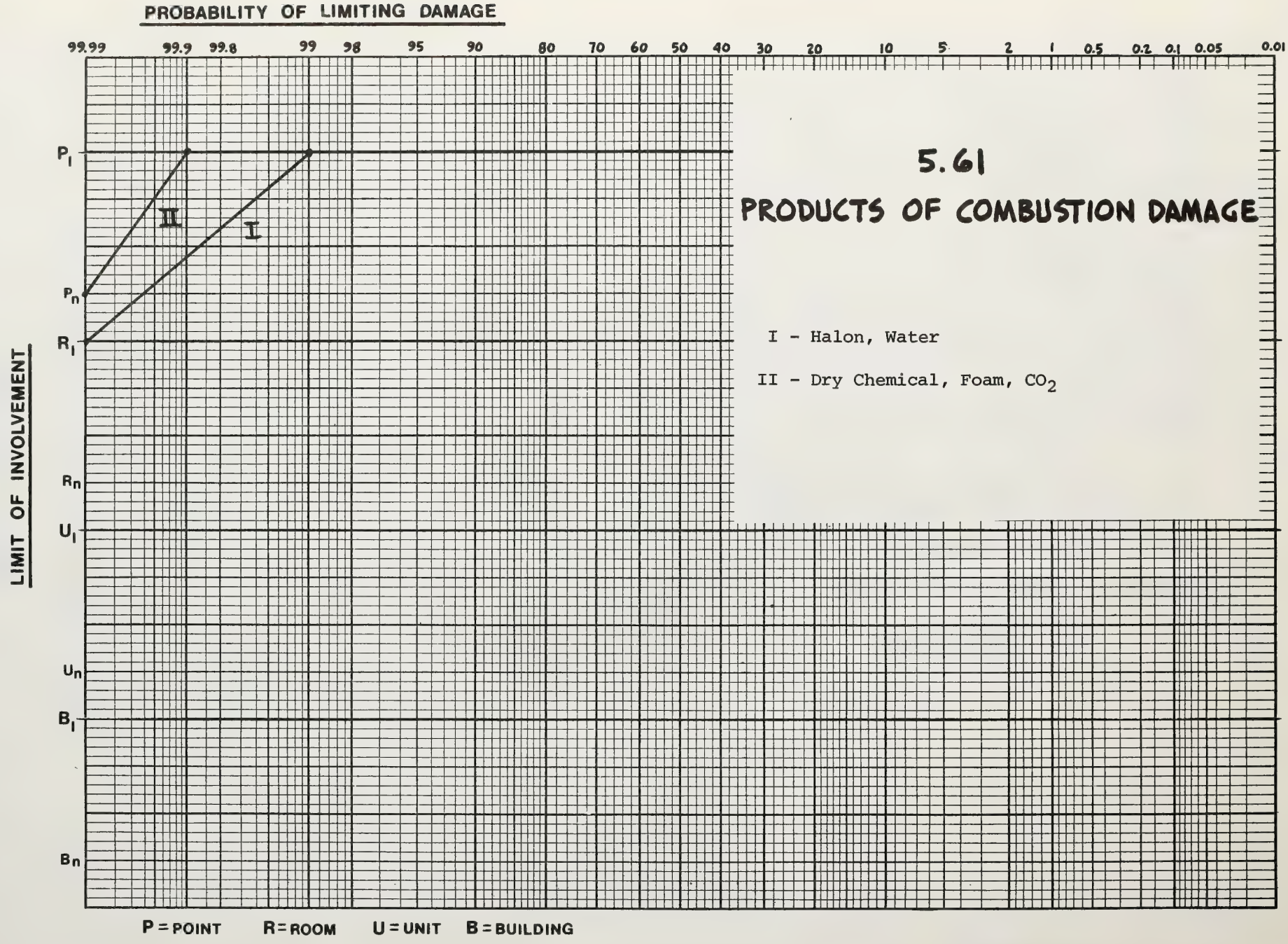


5.60 HXF, CO_2 H, DC

III-2.39 - Chart 5.61 - Products of Combustion Damage

III-2.39.1 Chart 5.61 expresses the damage caused by the increase in products of combustion generated during the control/extinguishing process. There will be a temporary increase in "smoke" development as the fire is controlled and extinguished.

III-2.39.2 The curves are based on judgment, considering available fire test data for the various systems.



5.61

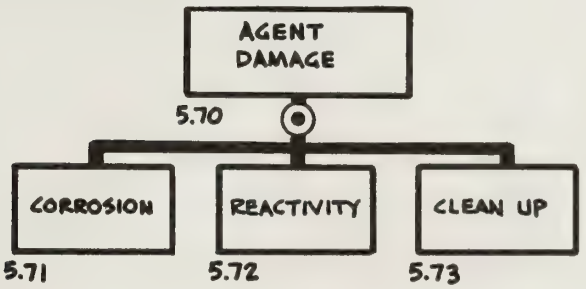
PRODUCTS OF COMBUSTION DAMAGE

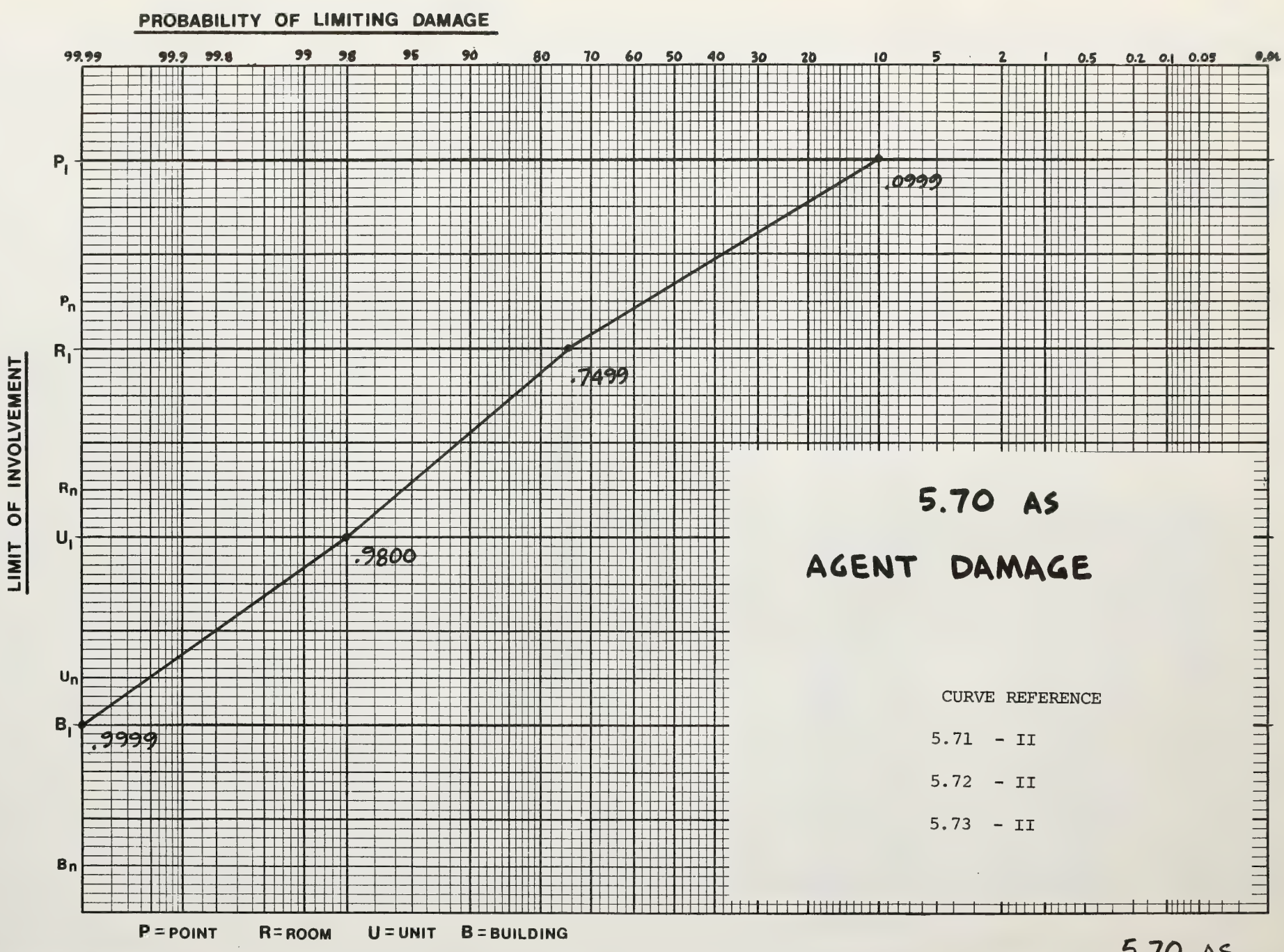
I - Halon, Water

II - Dry Chemical, Foam, CO_2

III-2.40 - Chart 5.70-AS Agent Damage

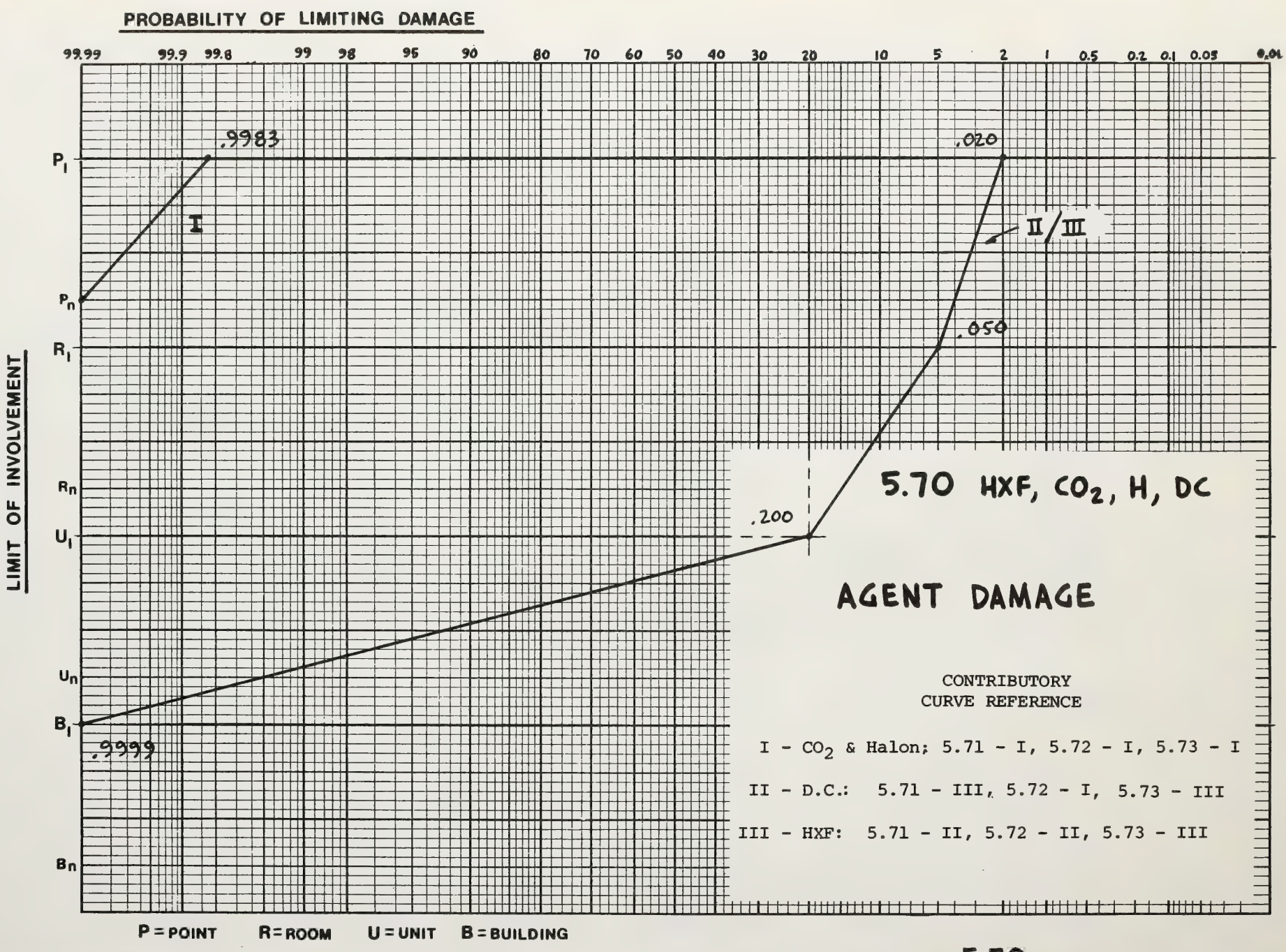
Chart 5.70-AS is an expression of the damage caused by sprinkler discharge water. It is the product of the agent corrosiveness, reactivity and clean-up potential combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0999
.7499
.9800
.9999
5.70 AS
AGENT DAMAGE
CURVE REFERENCE
5.71 - II
5.72 - II
5.73 - II
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.41 - Chart 5.70-HXF, CO2, H, DC Agent Damage

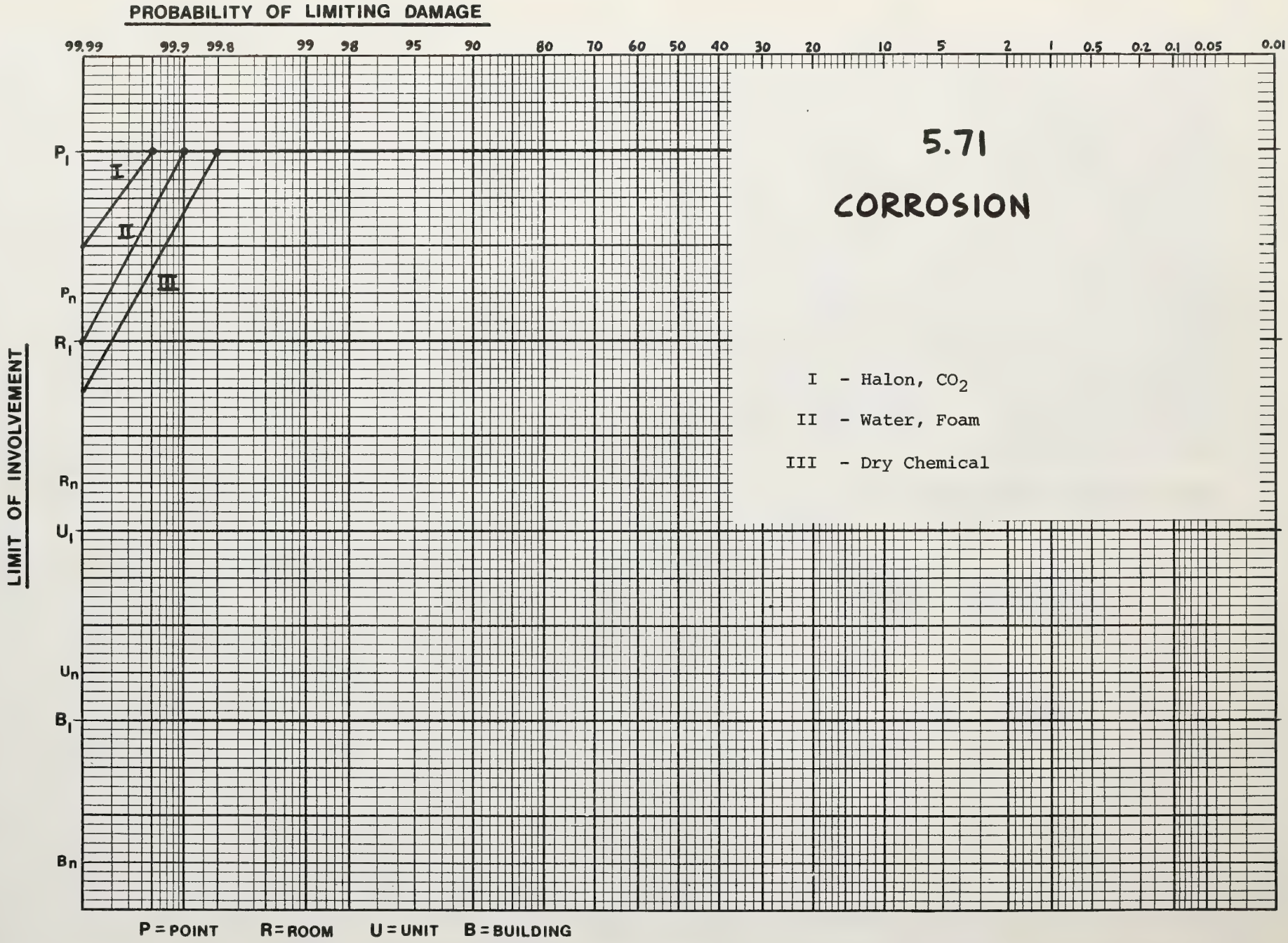
Chart 5.70-HXF, CO2, H, DC also expresses agent induced damage. The curves on this chart were developed in the same fashion as the curve on Chart 5.70 AS.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9983
I
.020
II/III
.050
.200
.9999
5.70 HXF, CO2, H, DC
AGENT DAMAGE
CONTRIBUTORY
CURVE REFERENCE
I - CO2 & Halon; 5.71 - I, 5.72 - I, 5.73 - I
II - D.C.: 5.71 - III, 5.72 - I, 5.73 - III
III - HXF: 5.71 - II, 5.72 - II, 5.73 - III
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.42 - Chart 5.71 - Corrosion

III-2.42.1 Chart 5.71 expresses the agent induced corrosive damage potential of the various agents being considered.

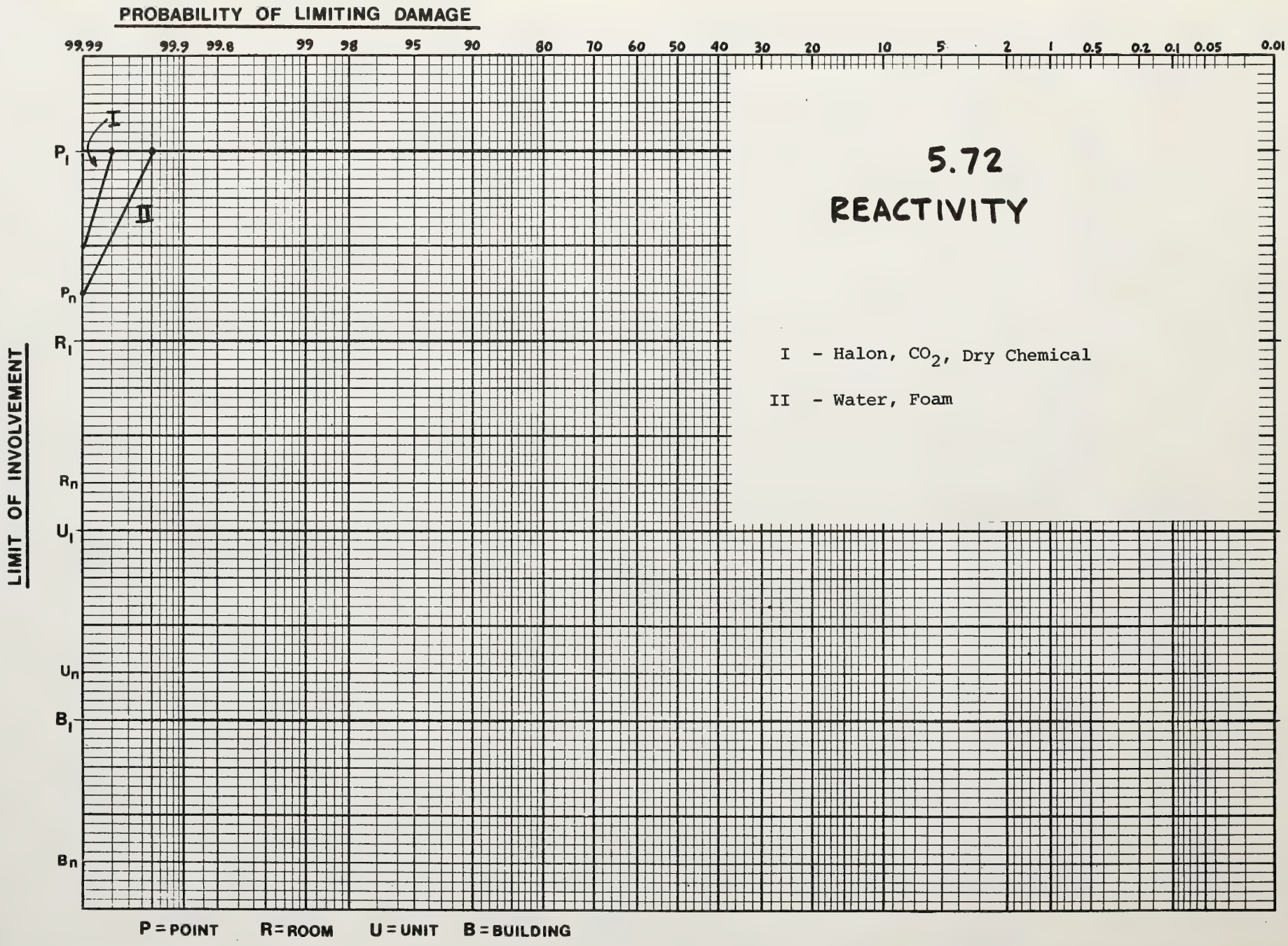
III-2.42.2 The curves are based on judgment, considering fire records and fire research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.71
CORROSION
I - Halon, CO2
II - Water, Foam
III - Dry Chemical
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.43 - Chart 5.72 - Reactivity

III-2.43.1 Chart 5.72 expresses the damage caused by reaction of the agent with the residential environment.

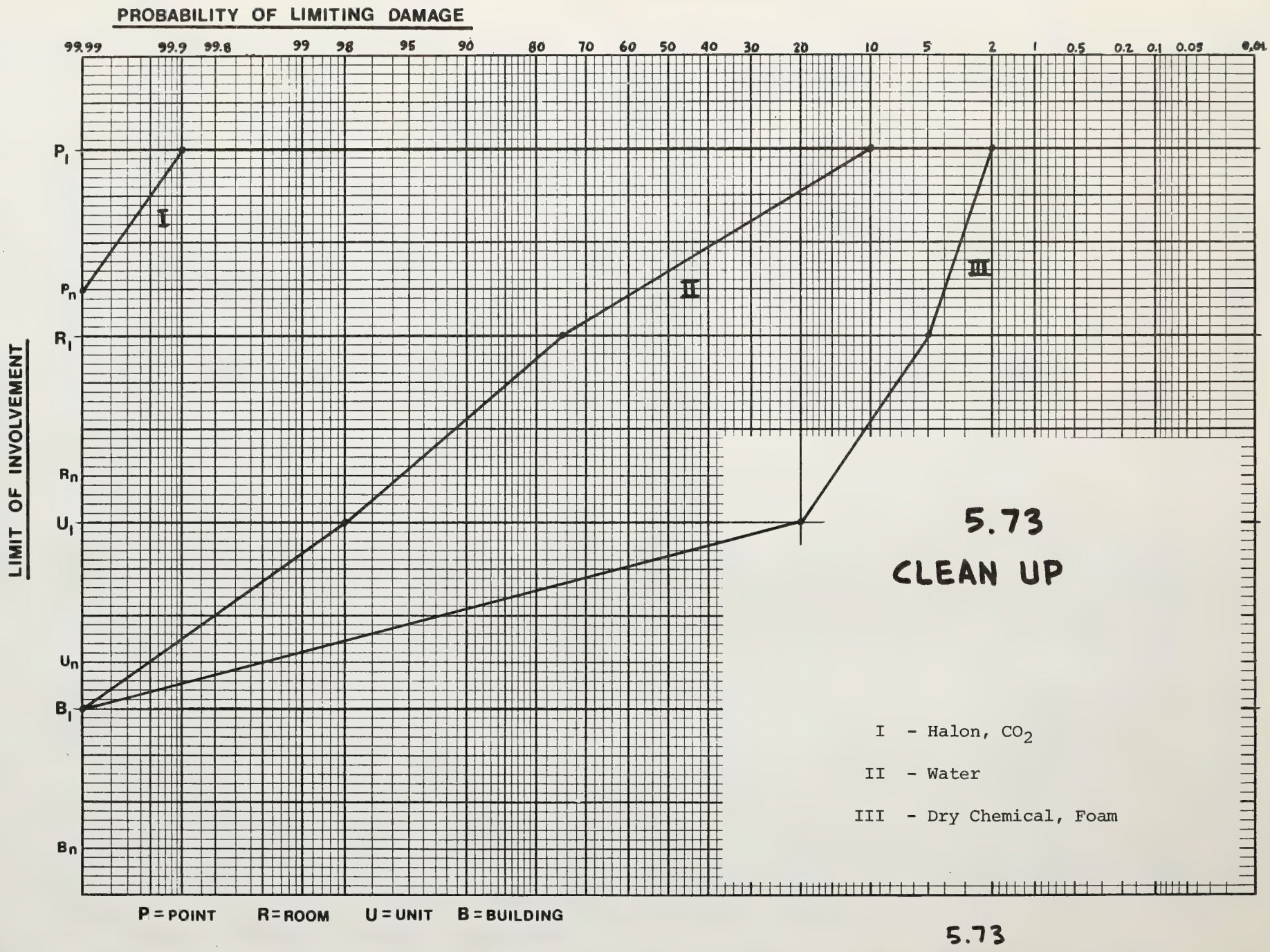
III-2.43.2 The curves are based on judgment, considering fire records and fire research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
5.72
REACTIVITY
I - Halon, CO2, Dry Chemical
II - Water, Foam
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.44 - Chart 5.73 - Clean-Up

III-2.44.1 Chart 5.73 expresses the damage caused by agent contamination of the residence during the control and extinguishing process.

III-2.44.2 The curves are based on judgment, considering fire records and fire research data.

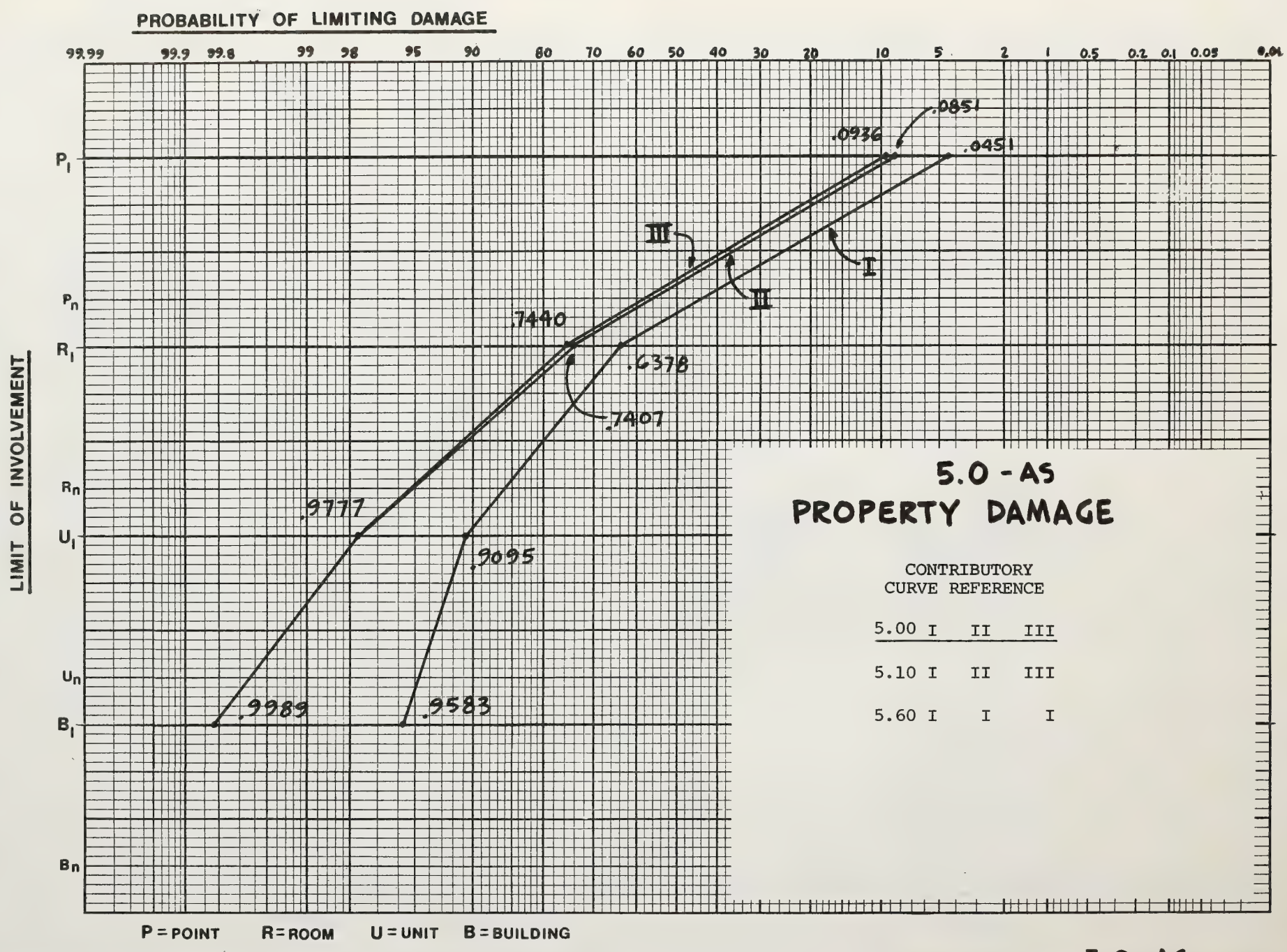

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
II
III
5.73
CLEAN UP
I - Halon, CO_2
II - Water
III - Dry Chemical, Foam
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.45 - Chart 5.0-AS Property Damage

III-2.45.1 Chart 5.0-AS is the expression of the ability of an automatic sprinkler system to limit both fire and side effects damage. Fire damage and side effects damage are combined through an "AND" gate to create this chart.

III-2.45.2 The curves show that the automatic sprinkler system will have a fair degree of success in limiting damage beyond the room of origin, but that the probability of damage occurring within the room of fire origin can be significant.

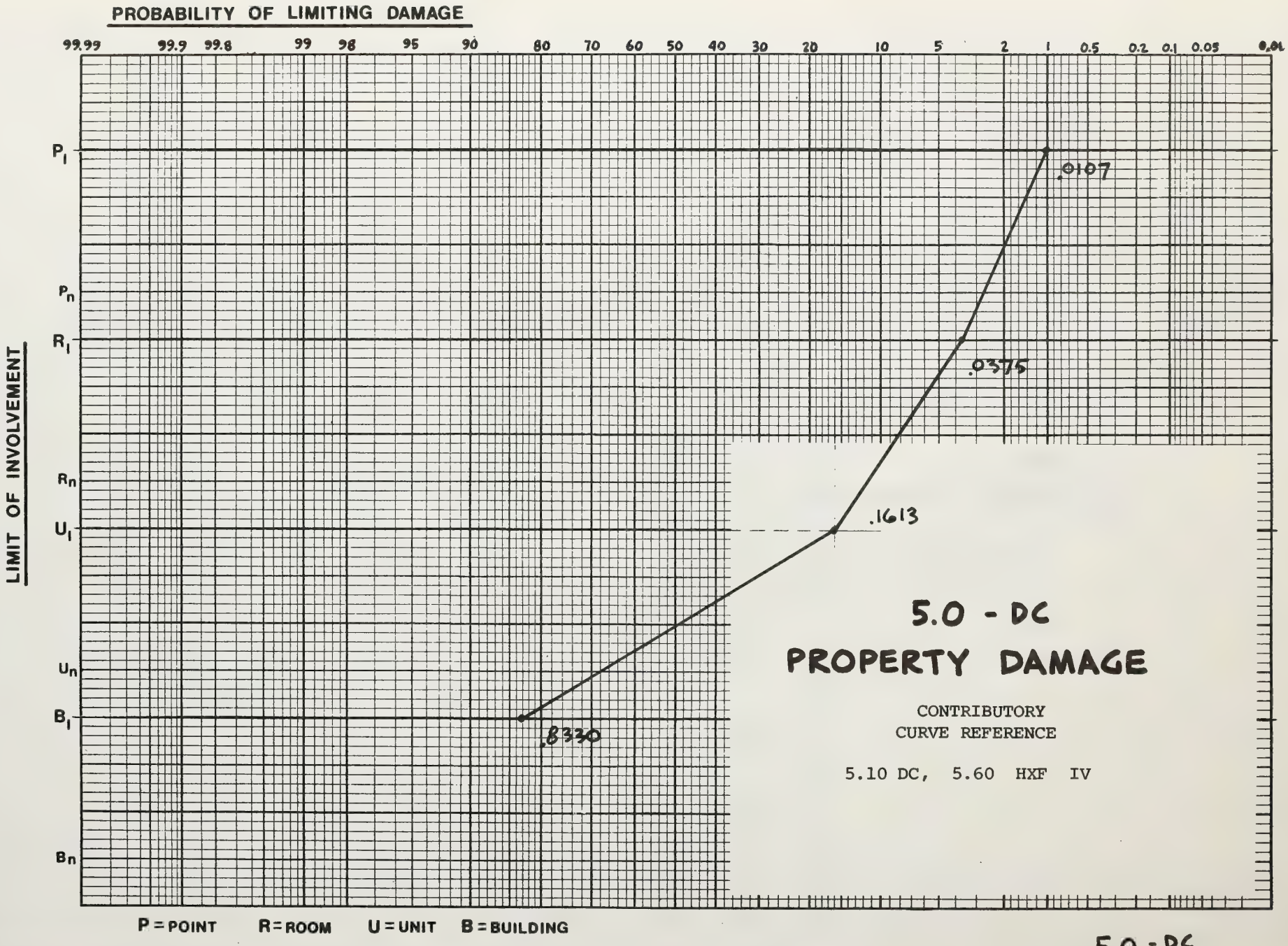
III-2.45.3 Curve I represents a Level I system, Curve II represents a Level II system and Curve III represents a Level III system.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0851
.0936
.0451
III
I
II
.7440
.6378
.7407
.9777
.9095
.9989
.9583
5.0 - AS
PROPERTY DAMAGE
CONTRIBUTORY
CURVE REFERENCE
5.00 I II III
5.10 I II III
5.60 I I I
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.46 - Chart 5.0-DC Property Damage

III-2.46.1 Chart 5.0-DC expresses the probability of limiting total damage with a dry chemical system. The water sprinkler described by Chart 5.0-AS is significantly better in limiting total damage than the dry chemical system.

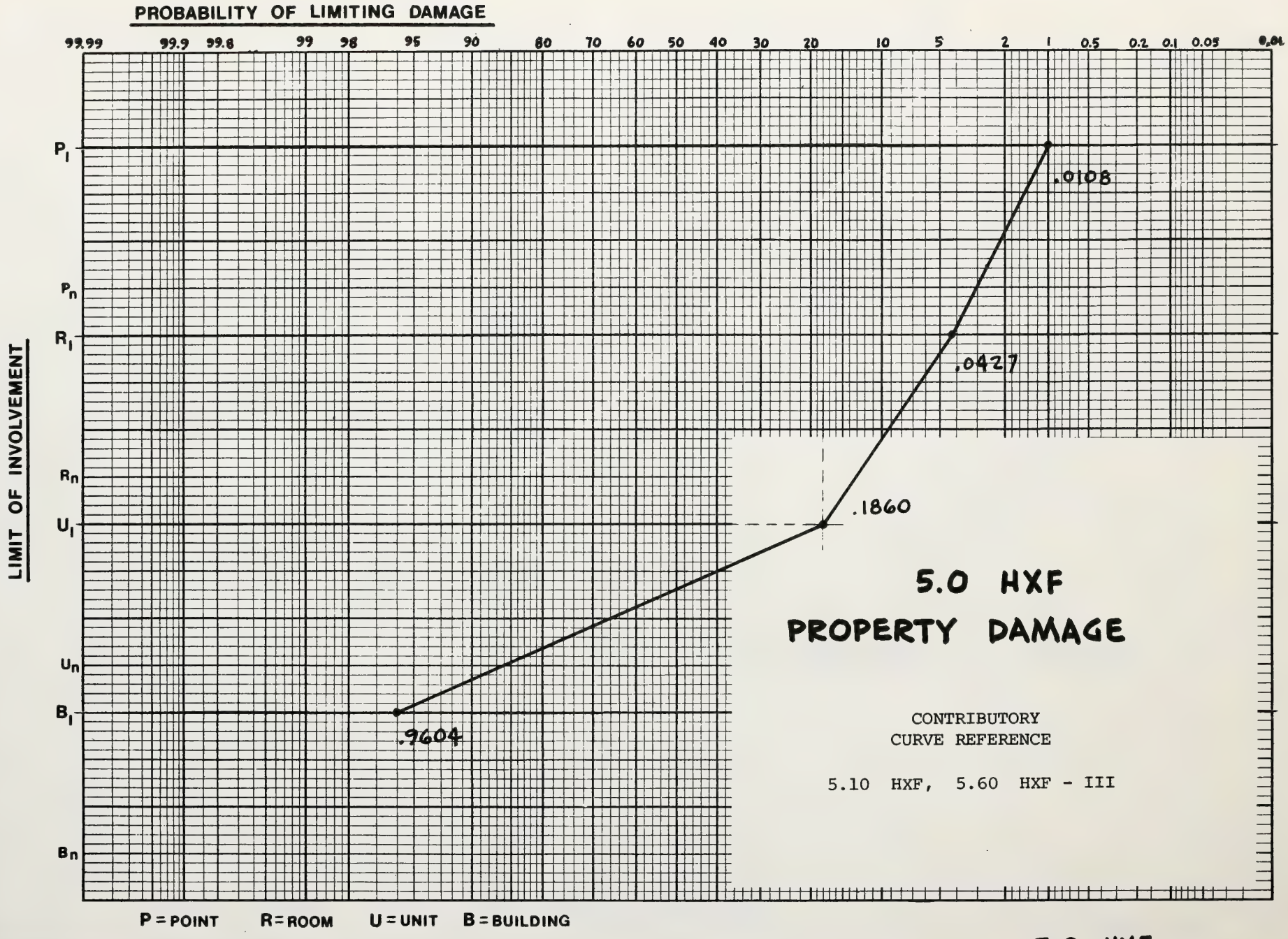
III-2.46.2 The curve is developed in the same fashion as the curve on Chart 5.0 AS.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0107
.0375
.1613
.8330
5.0 - DC
PROPERTY DAMAGE
CONTRIBUTORY
CURVE REFERENCE
5.10 DC, 5.60 HXF IV
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.47 - Chart 5.0-HXF Property Damage

III-2.47.1 Chart 5.0-HXF shows that high expansion foam systems are significantly less effective in limiting total damage than the sprinkler system.

III-2.47.2 The curve is developed in the same fashion as the curve on Chart 5.0 AS.

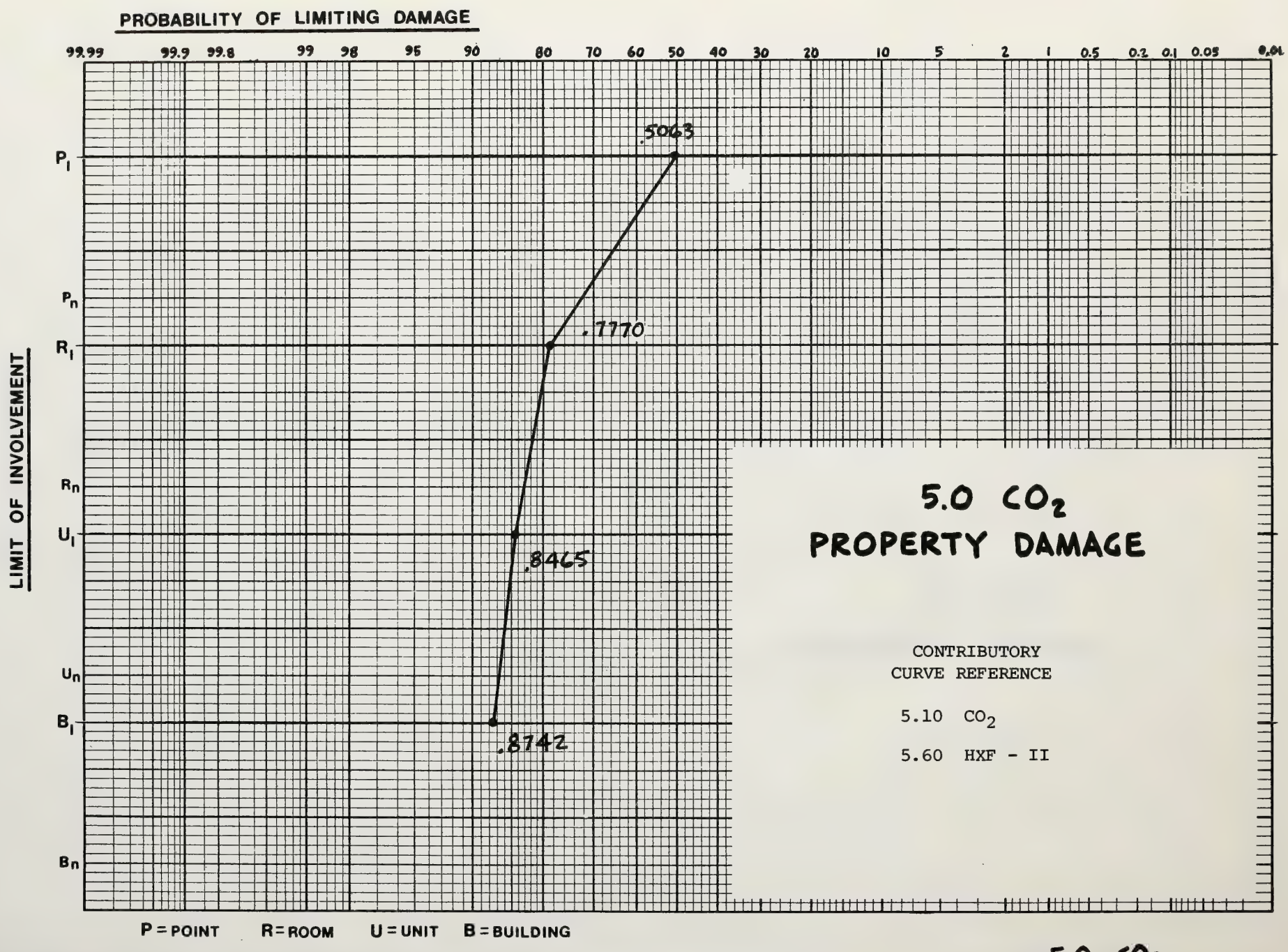

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.0108
.0427
.1860
.9604
5.0 HXF
PROPERTY DAMAGE
CONTRIBUTORY
CURVE REFERENCE
5.10 HXF, 5.60 HXF - III
P = POINT R = ROOM U = UNIT B = BUILDING

5.0 HXF

III-2.48 - Chart 5.0-CO2 Property Damage

III-2.48.1 Chart 5.0-CO2 shows that the CO2 system can be comparable to or better than a sprinkler system in limiting total property damage.

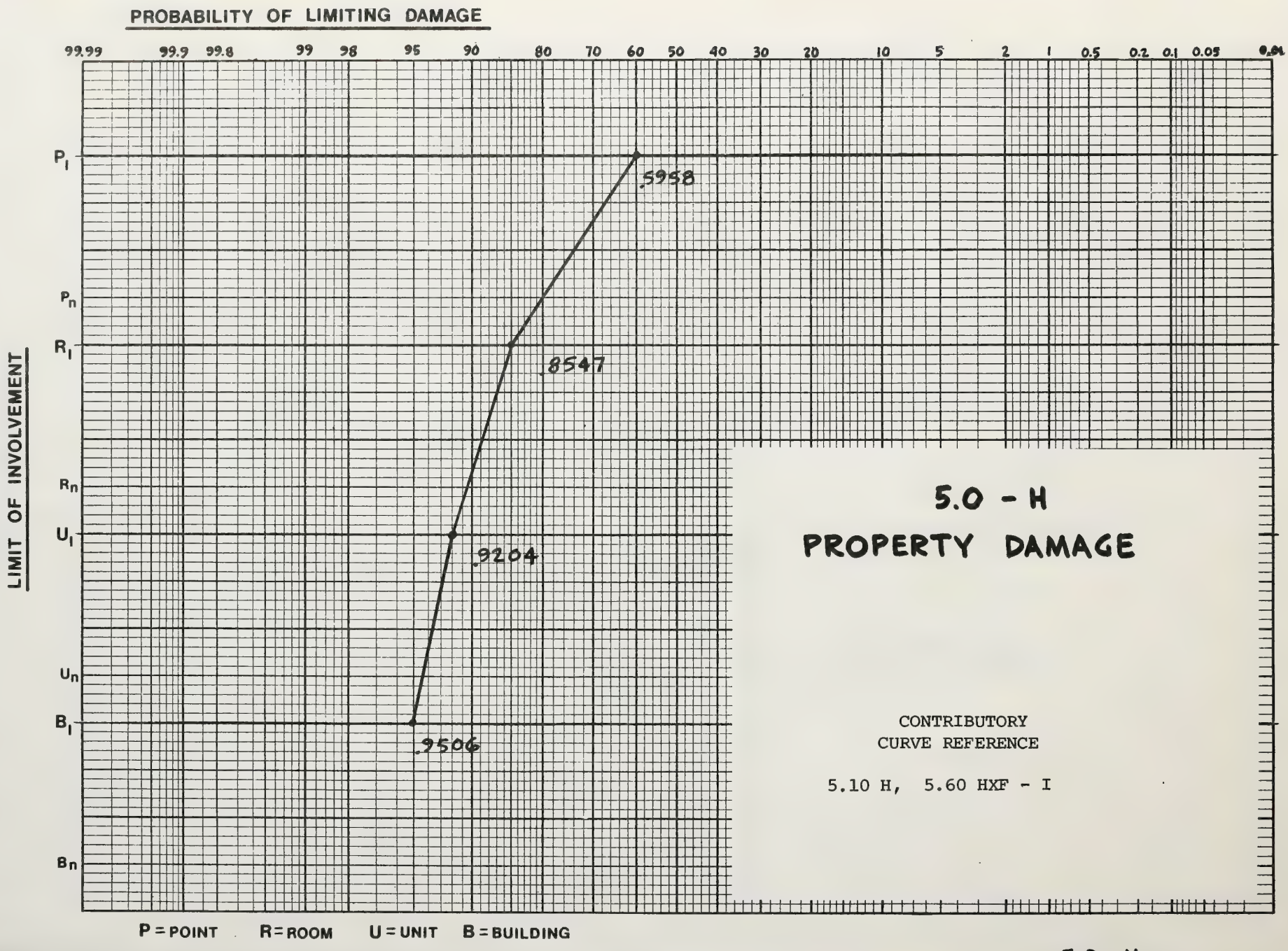
III-2.48.2 The curve is developed in the same fashion as the curve on Chart 5.0 AS.


PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.5063
.7770
.8465
.8742
5.0 CO2
PROPERTY DAMAGE
CONTRIBUTORY
CURVE REFERENCE
5.10 CO2
5.60 HXF - II
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.49 - Chart 5.0-H Property Damage

III-2.49.1 Chart 5.0-H shows that halon systems can also be comparable to or better than a sprinkler system in limiting total property damage.

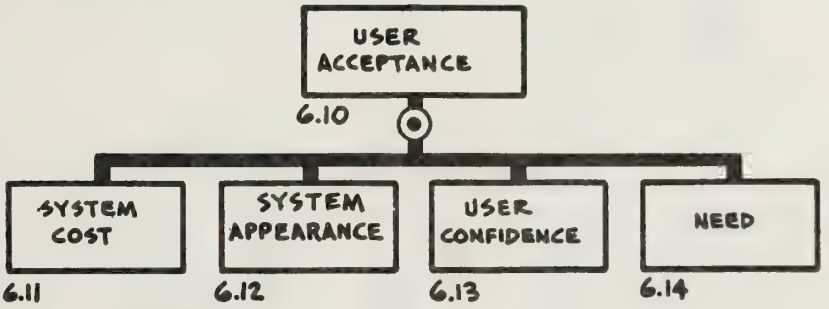
III-2.49.2 The curve is developed in the same fashion as the curve on Chart 5.0 AS.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.5958
.8547
.9204
.9506
5.0 - H
PROPERTY DAMAGE
CONTRIBUTORY
CURVE REFERENCE
5.10 H, 5.60 HXF - I
P = POINT R = ROOM U = UNIT B = BUILDING

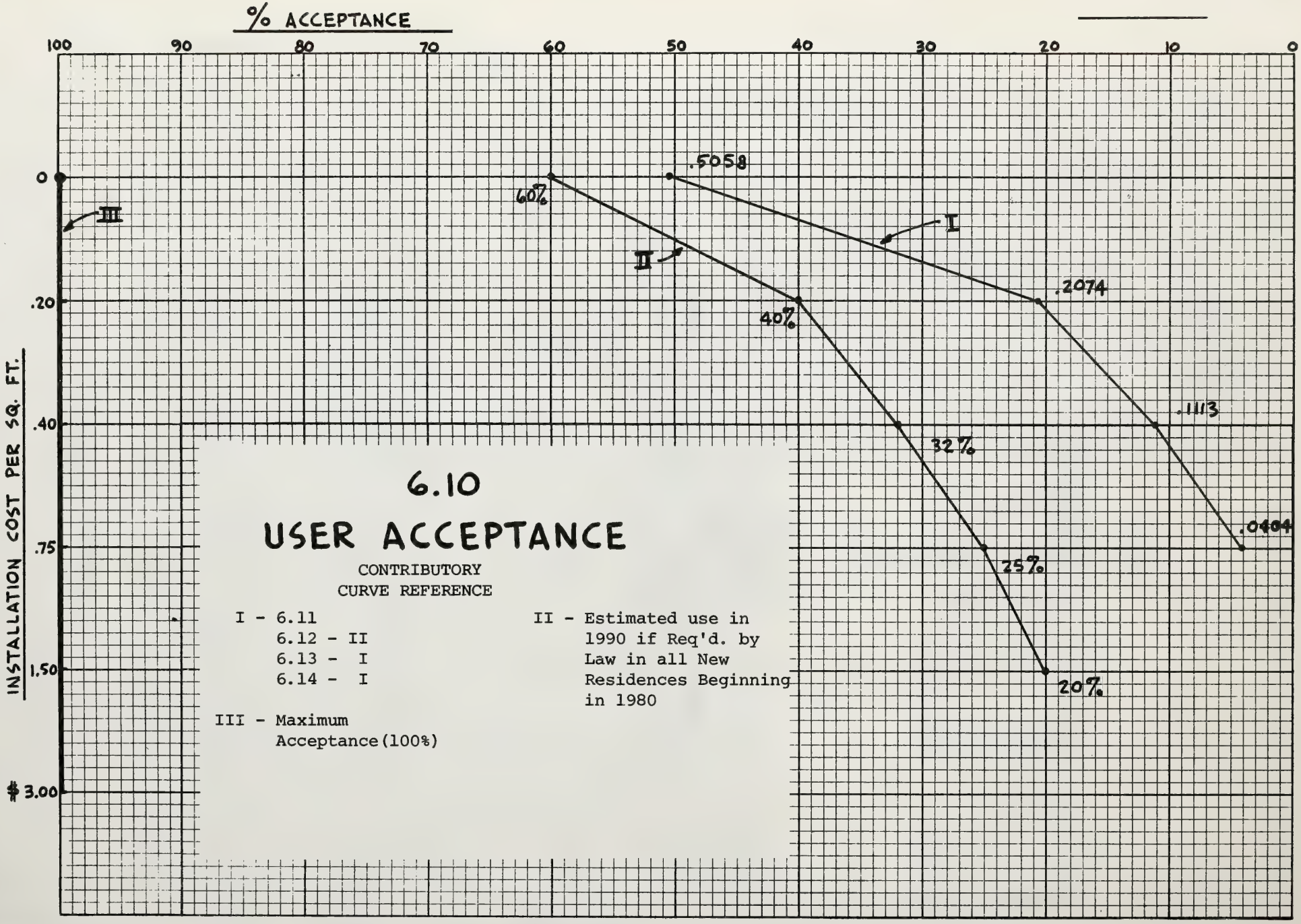
III-2.50 - Chart 6.10 - User Acceptance

III-2.50.1 Chart 6.10 predicts the acceptance of suppression systems as a function of the system installation cost.

III-2.50.2 The curves are the product of cost, system appearance, user confidence and user perception of need combined through an "AND" gate.



III-2.50.3 Curve I represents voluntary system acceptance in 1990. Curve II represents system acceptance in 1990 assuming all new residential units are required by law to have systems. Curve III represents 100% system acceptance.



6.10

USER ACCEPTANCE

CONTRIBUTORY
CURVE REFERENCE

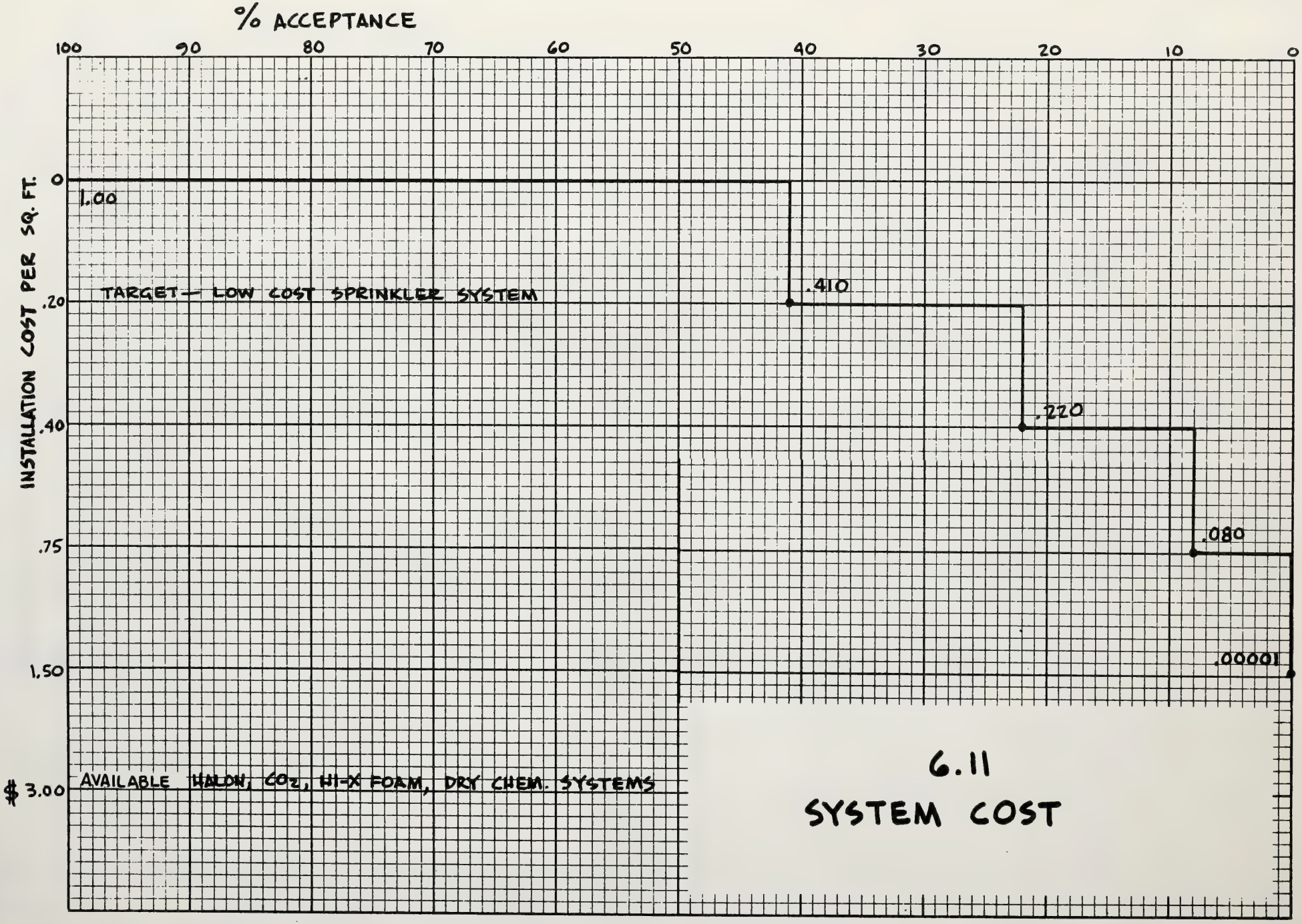
I - 6.11
6.12 - II
6.13 - I
6.14 - I

II - Estimated use in 1990 if Req'd. by Law in all New Residences Beginning in 1980

III - Maximum Acceptance (100%)

III-2.51 - Chart 6.11 - System Cost

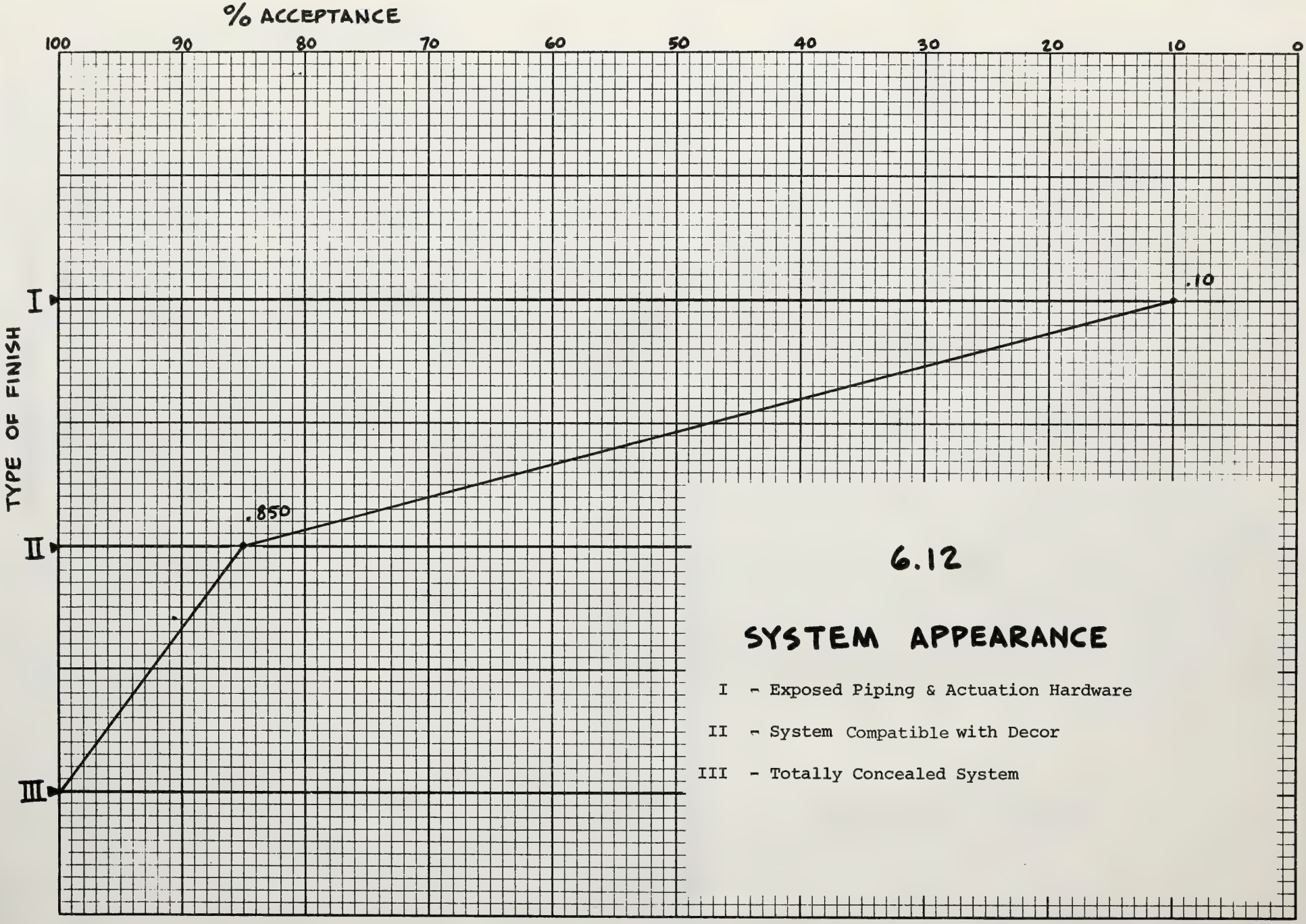
Chart 6.11 expresses the acceptance (use) of automatic suppression systems as a function of the system installation cost. The curve was developed through interviews with potential system users throughout the country (3-4.2).



6.11
SYSTEM COST

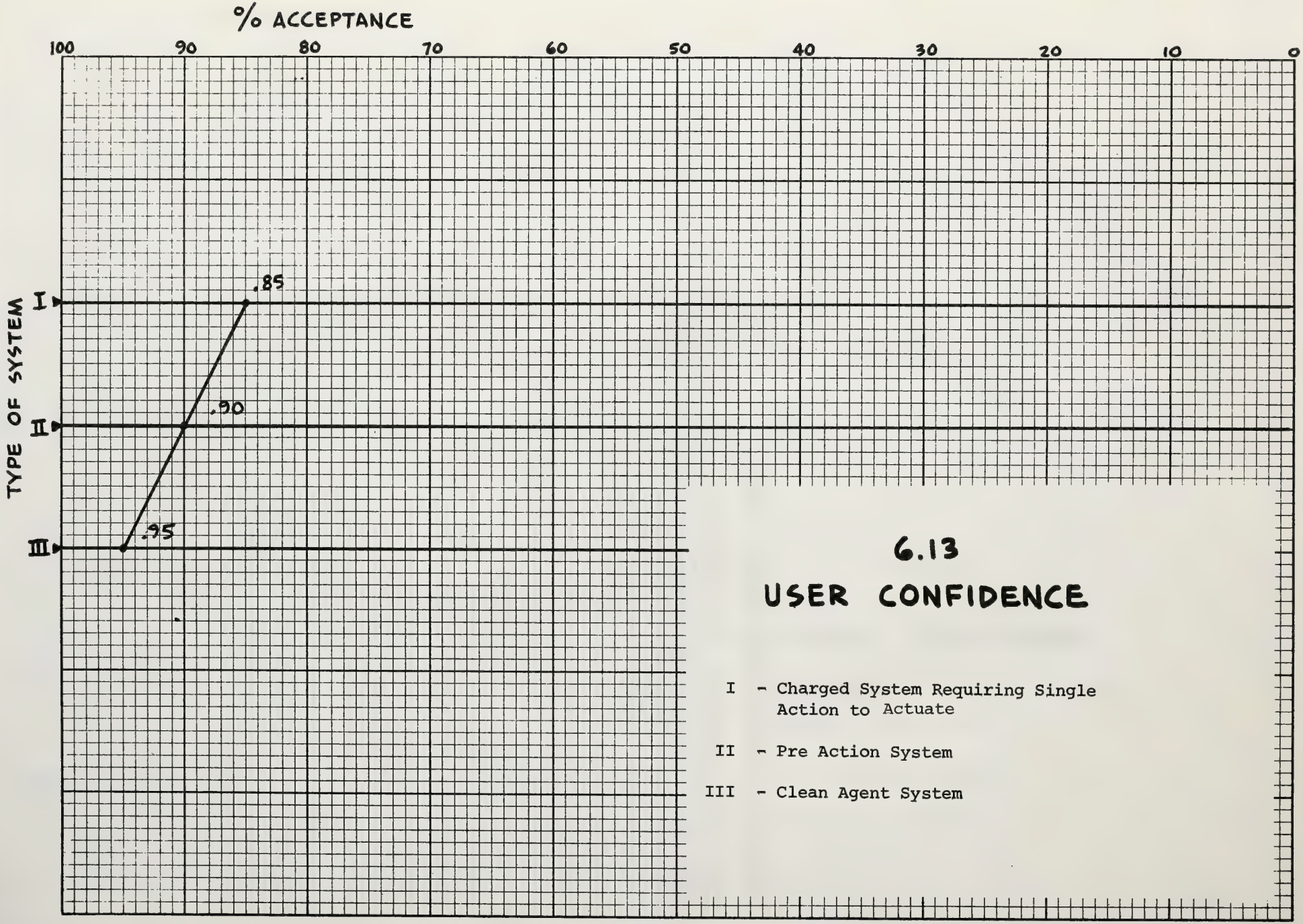
III-2.52 - Chart 6.12 - System Appearance

Chart 6.12 expresses the acceptability of a suppression system as a function of the appearance of the system. The curve was developed based on judgment considering interviews with potential system users throughout the country (3-4.9).


% ACCEPTANCE
100
90
80
70
60
50
40
30
20
10
0
TYPE OF FINISH
I
II
III
.10
.850
6.12
SYSTEM APPEARANCE
I - Exposed Piping & Actuation Hardware
II - System Compatible with Decor
III - Totally Concealed System

III-2.53 - Chart 6.13 - User Confidence

Chart 6.13 expresses the confidence that potential users have in the ability of the system to operate only when necessary. This curve was developed through interviews with potential system users throughout the country (3-4.6, 3-4.10).



6.13
USER CONFIDENCE

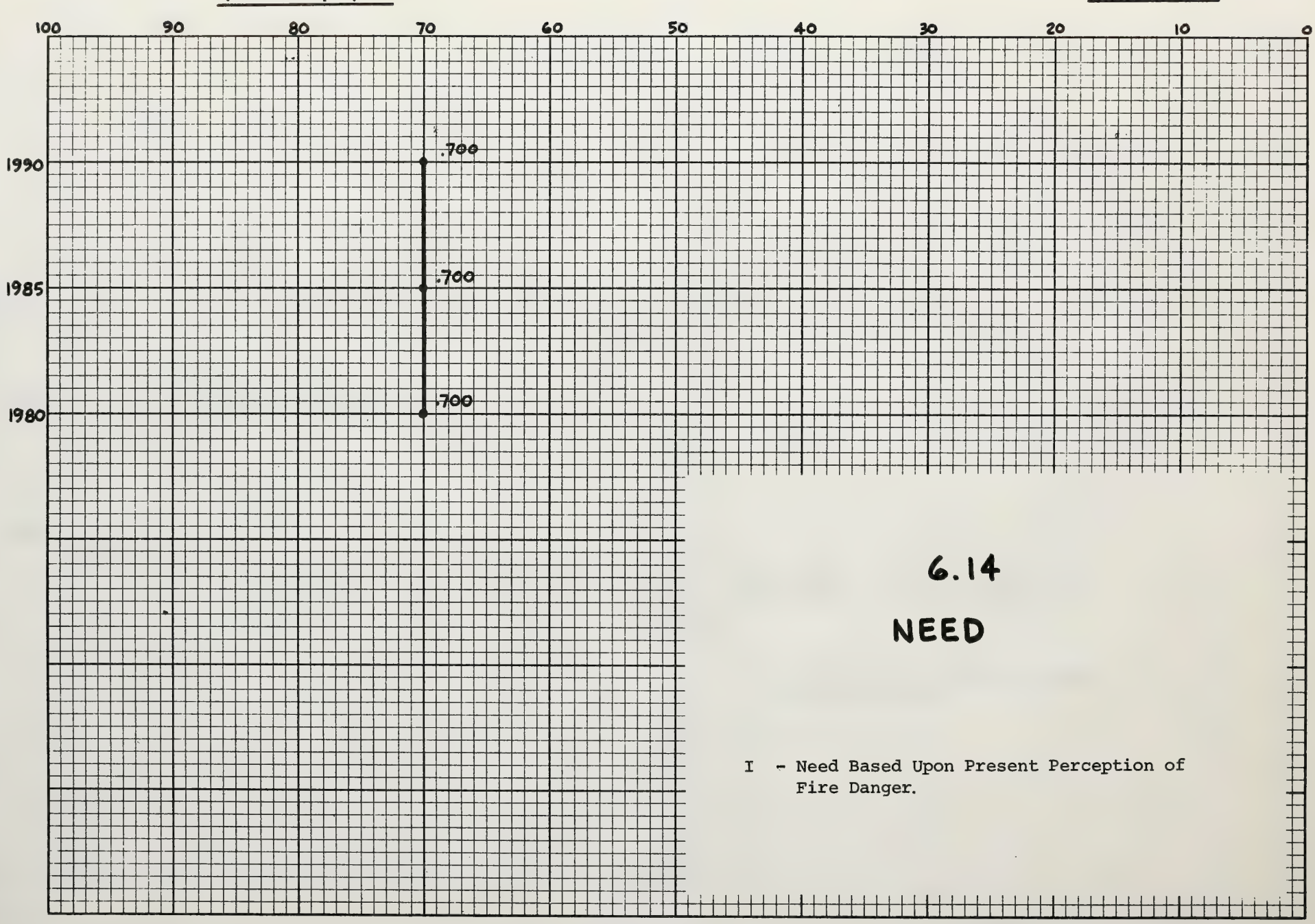
I - Charged System Requiring Single Action to Actuate

II - Pre Action System

III - Clean Agent System

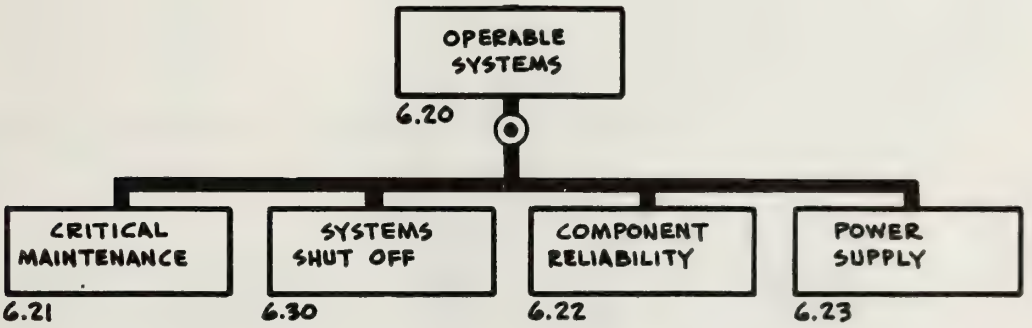
III-2.54 - Chart 6.14 - Need

Chart 6.14 expresses the acceptability of a system. This curve was developed through interviews with potential system users throughout the country (3-4.11).


% ACCEPTANCE
100
90
80
70
60
50
40
30
20
10
0
1990
1985
1980
.700
.700
.700
6.14
NEED
I - Need Based Upon Present Perception of Fire Danger.

III-2.55 - Chart 6.20 - Operable Systems

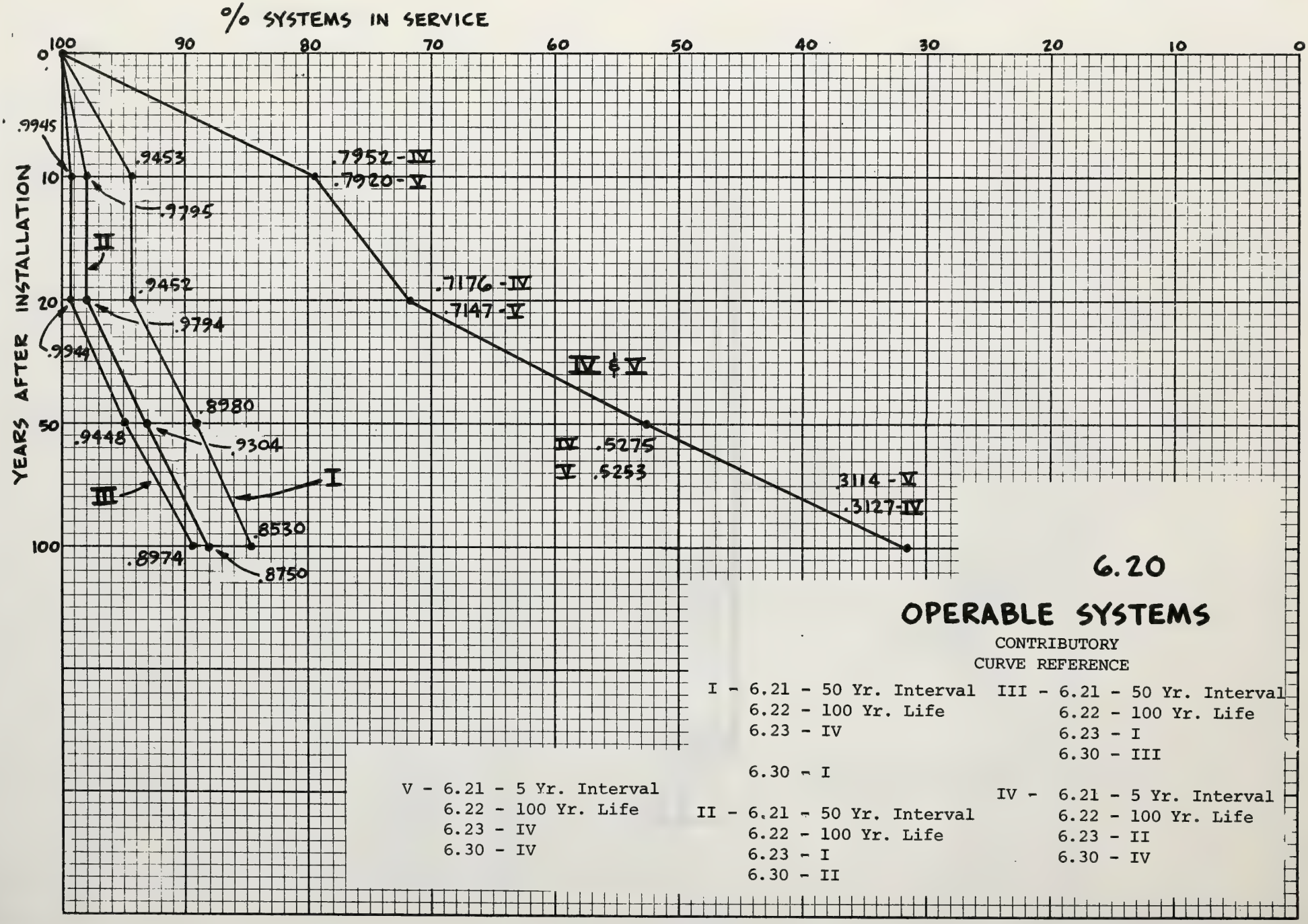
III-2.55.1 Chart 6.20 expresses the percent of systems installed which will be operable as a function of time after the systems have been installed. The curves are the product of maintenance requirements, component reliability, system power supply and systems shut off combined through an "AND" gate.



III-2.55.2 Curve I represents a Level I sprinkler system; Curve II, a Level II sprinkler system, and Curve III, a Level III sprinkler system.

III-2.55.3 Curve IV represents a stored pressure halon, dry chemical or carbon dioxide system which relies upon stored pressure for agent discharge power and which requires routine maintenance.

III-2.55.4 Curve V represents a high expansion foam system which relies upon a pump.



6.20

OPERABLE SYSTEMS

CONTRIBUTORY CURVE REFERENCE

I - 6.21 - 50 Yr. Interval
6.22 - 100 Yr. Life
6.23 - IV
6.30 - I

II - 6.21 - 50 Yr. Interval
6.22 - 100 Yr. Life
6.23 - I
6.30 - II

III - 6.21 - 50 Yr. Interval
6.22 - 100 Yr. Life
6.23 - I
6.30 - III

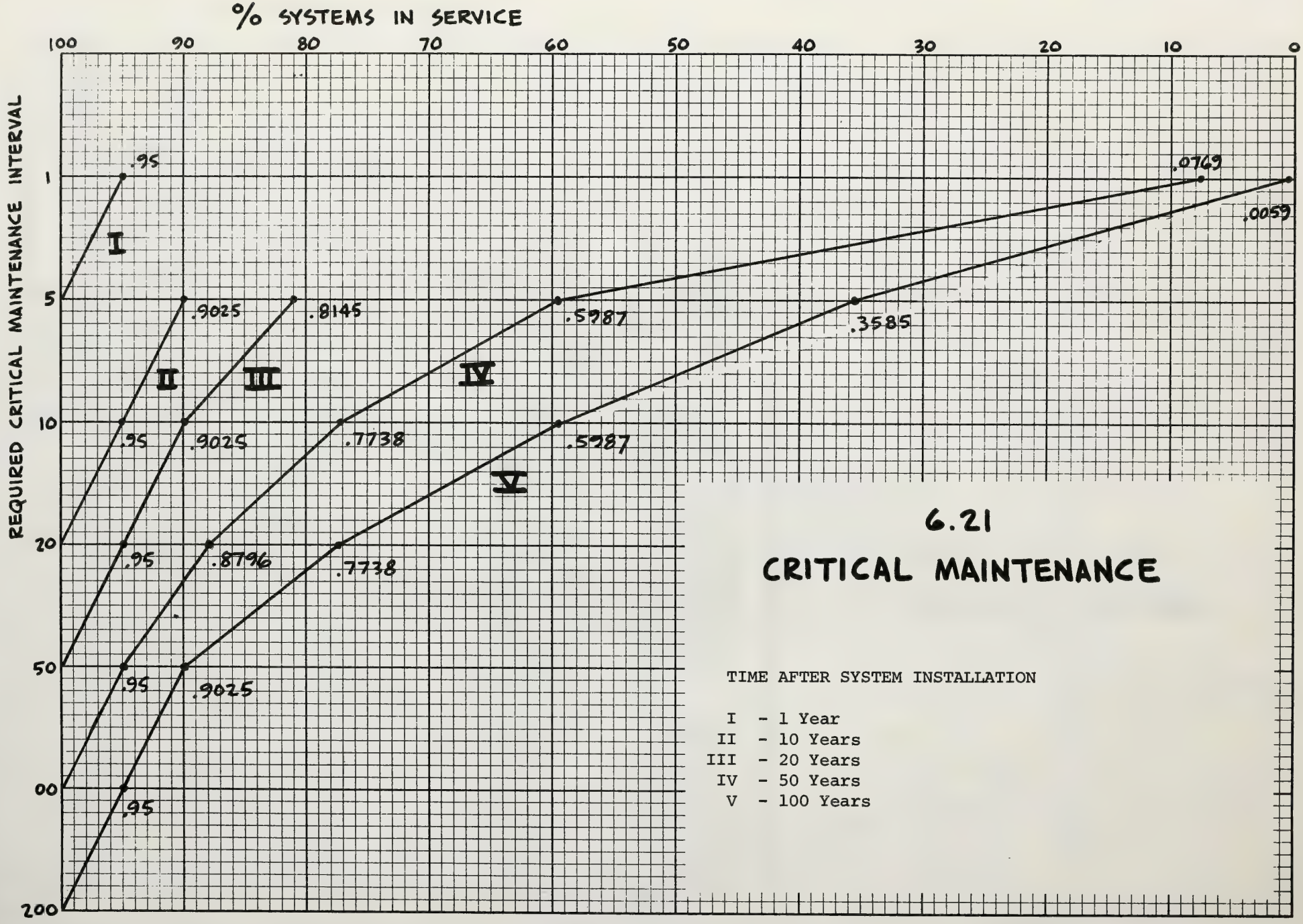
IV - 6.21 - 5 Yr. Interval
6.22 - 100 Yr. Life
6.23 - II
6.30 - IV

V - 6.21 - 5 Yr. Interval
6.22 - 100 Yr. Life
6.23 - IV
6.30 - IV

III-2.56 - Chart 6.21 - Critical Maintenance

III-2.56.1 Chart 6.21 expresses the percent of installed systems which will be operable as a function of maintenance requirements and system age. These curves are based on the reported 95% maintenance success rate (17) that is attributed to residential fire detectors (i.e. 95% of the detectors requiring annual maintenance are serviced each year.)

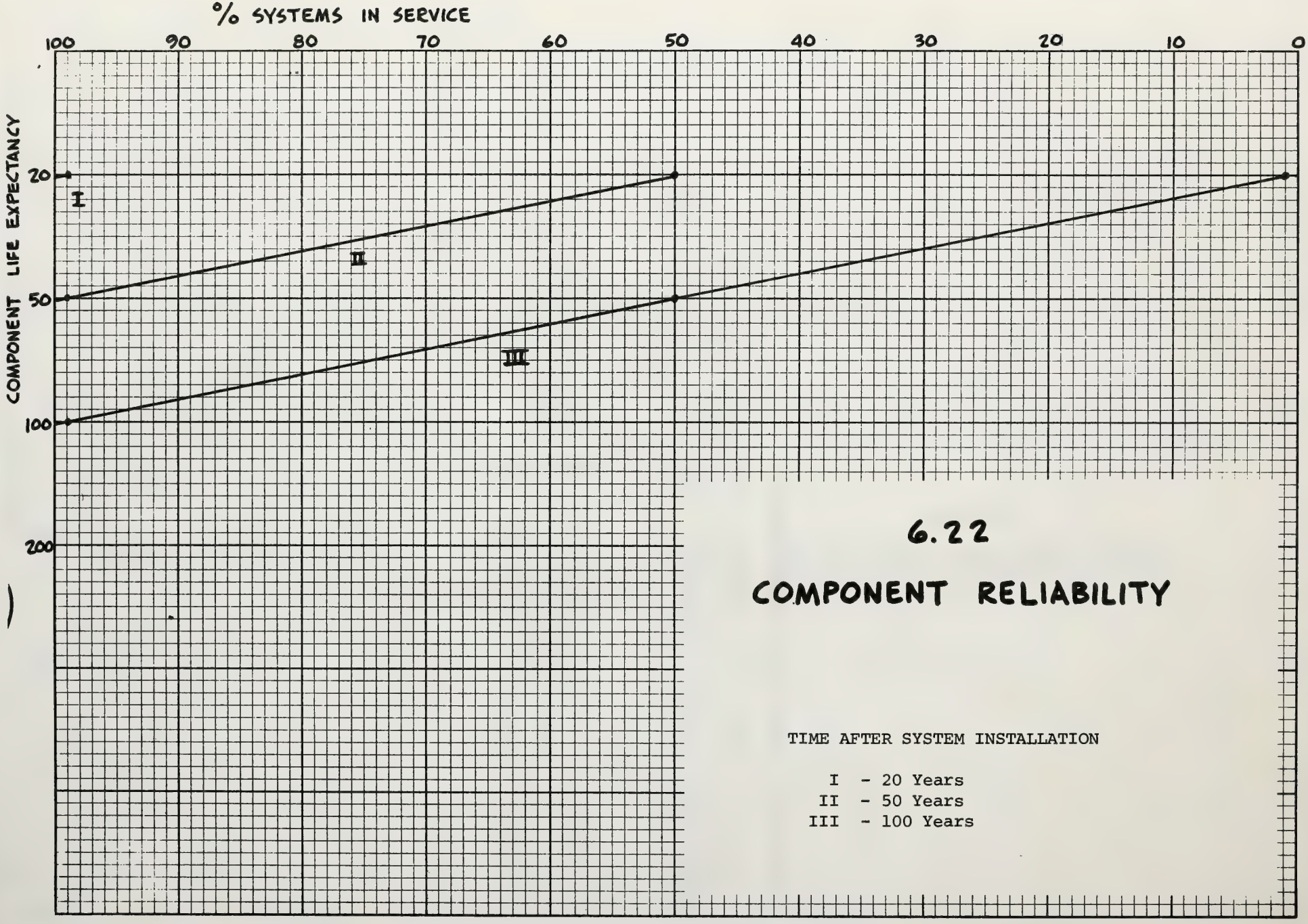
III-2.56.2 Suppression systems should not need critical maintenance more often than every 50 years (MAPL). The reason for this interval is the maintenance failure rate experienced by detectors and the stated unacceptability of maintenance by potential users (3-4.4).


% SYSTEMS IN SERVICE
100
90
80
70
60
50
40
30
20
10
0
REQUIRED CRITICAL MAINTENANCE INTERVAL
1
5
10
20
50
00
200
I
II
III
IV
V
.95
.9025
.8145
.5787
.3585
.0749
.0059
.95
.9025
.7738
.5787
.95
.8796
.7738
.95
.9025
.95
6.21
CRITICAL MAINTENANCE
TIME AFTER SYSTEM INSTALLATION
I - 1 Year
II - 10 Years
III - 20 Years
IV - 50 Years
V - 100 Years

III-2.57 - Chart 6.22 - Component Reliability

III-2.57.1 Chart 6.22 expresses the percent of systems operable as a function of the life expectancy of system components and the system age. The curves were developed based upon an assumed 1% failure rate at the end of component life expectancy and a 50% failure rate at double the component life expectancy.

III-2.57.2 System components should be designed for a minimum 100 year life expectancy (MAPL). The reason for this also lies in the unacceptability of routine maintenance (3-4.4) and the need for a system which will last as long as the residence in which it is installed.



6.22

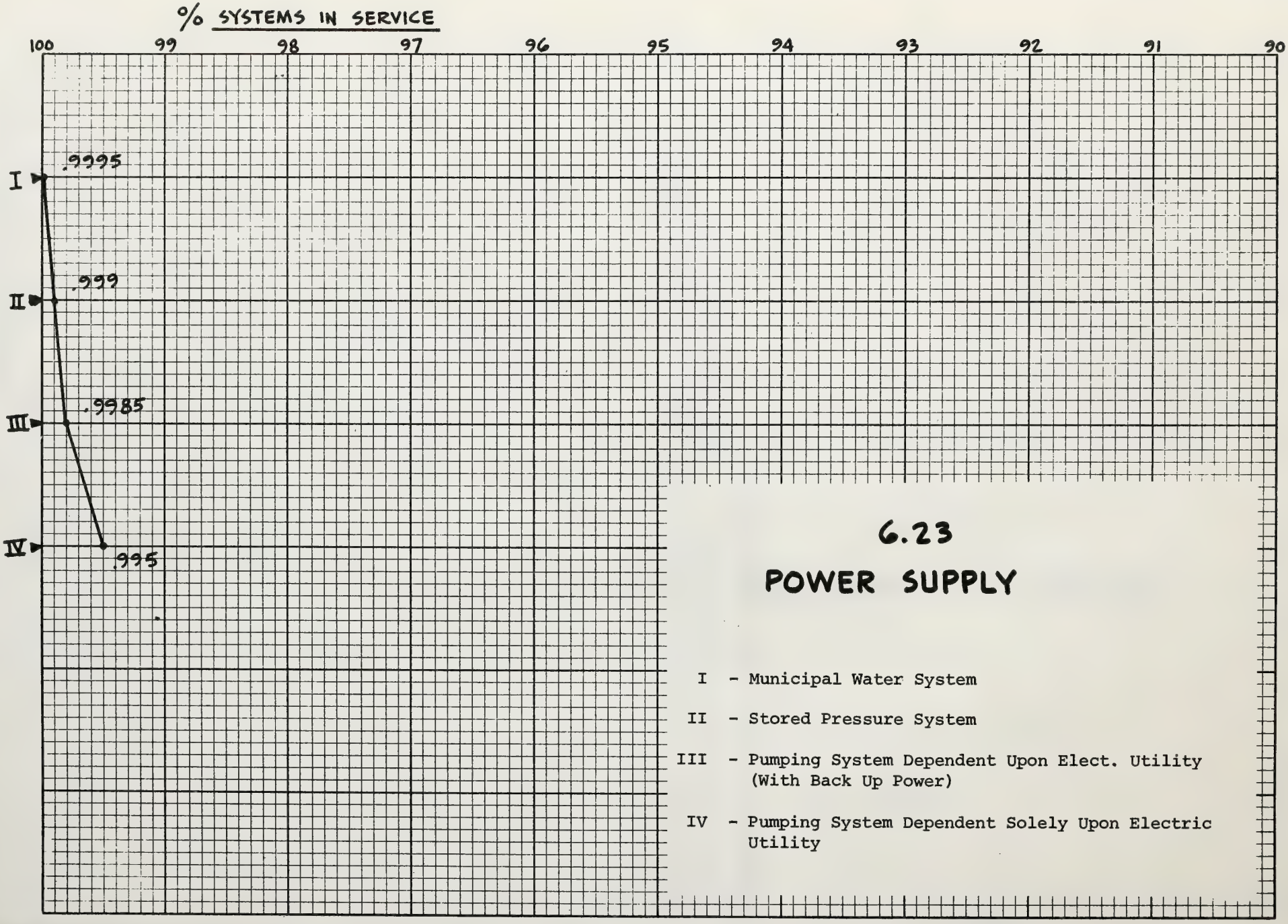
COMPONENT RELIABILITY

TIME AFTER SYSTEM INSTALLATION

I - 20 Years
II - 50 Years
III - 100 Years

III-2.58 - Chart 6.23 - Power Supply

Chart 6.23 expresses the percent of systems operable as a function of the type of power used to propel the extinguishing agent. The curve was developed based upon judgment of projected utility outages and pressurized system failure experience.



6.23
POWER SUPPLY

I - Municipal Water System

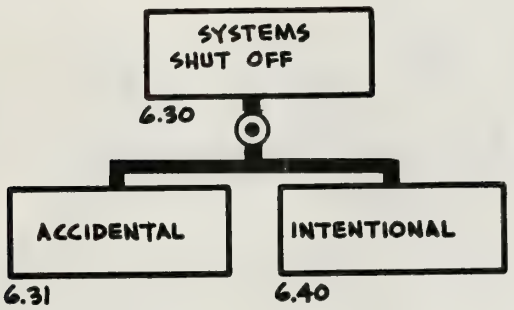
II - Stored Pressure System

III - Pumping System Dependent Upon Elect. Utility (With Back Up Power)

IV - Pumping System Dependent Solely Upon Electric Utility

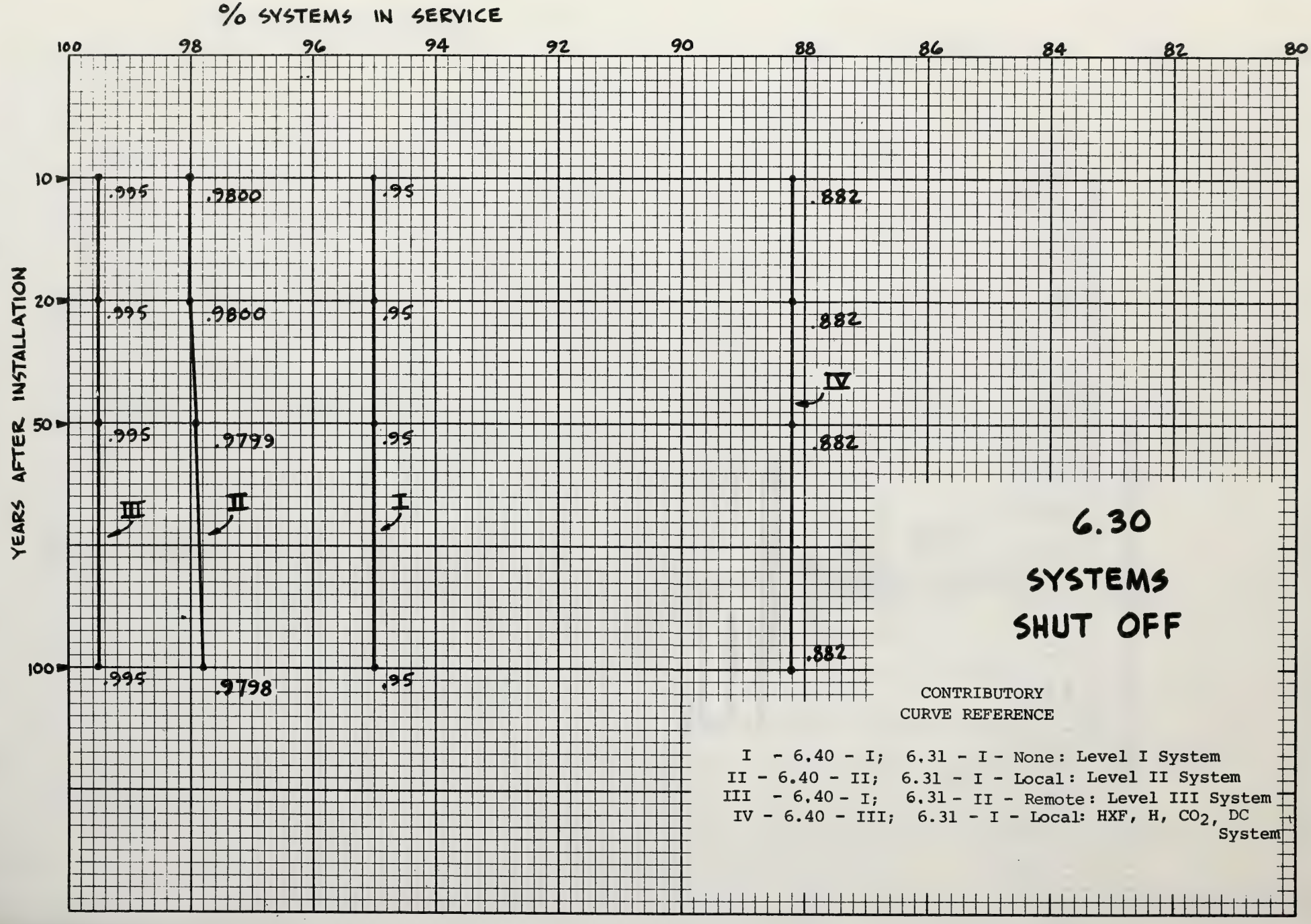
III-2.59 - Chart 6.30 - Systems Shut Off

III-2.59.1 Chart 6.30 shows the percentage of systems which will be shut off as a function of system age. The curves are developed using the curves for systems which are accidentally shut off and systems which are intentionally shut off combined through an "AND" gate.



III-2.59.2

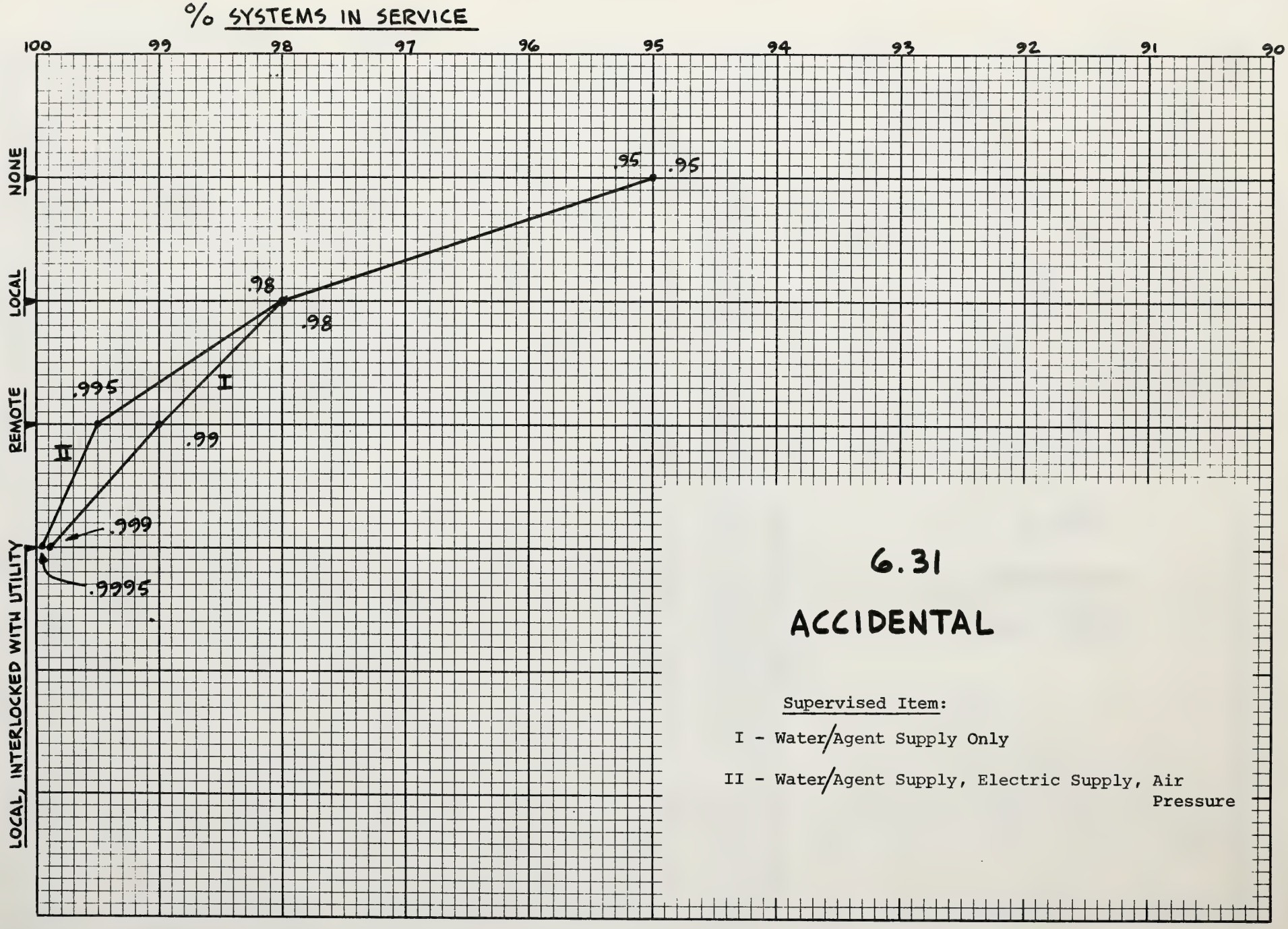
- Curve I represents a Level I sprinkler system;
- Curve II, a Level II sprinkler system;
- Curve III, a Level III sprinkler system;
- Curve IV, a Halon, HXF, CO2, or DC system.


% SYSTEMS IN SERVICE
100
98
96
94
92
90
88
86
84
82
80
YEARS AFTER INSTALLATION
10
20
50
100
.995
.9800
.95
.882
.9799
.9798
III
II
I
IV
6.30
SYSTEMS
SHUT OFF
CONTRIBUTORY
CURVE REFERENCE
I - 6.40 - I; 6.31 - I - None: Level I System
II - 6.40 - II; 6.31 - I - Local: Level II System
III - 6.40 - I; 6.31 - II - Remote: Level III System
IV - 6.40 - III; 6.31 - I - Local: HXF, H, CO_2, DC System

III-2.60 - Chart 6.31 - Accidental

III-2.60.1 This chart shows the percentage of systems which will be operable as a function of the type of supervision provided.

III-2.60.2 The curves are based on sprinkler system performance records (35) and estimated utility outages.



6.31

ACCIDENTAL

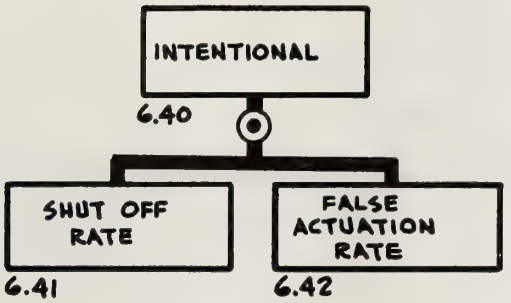
Supervised Item:

I - Water/Agent Supply Only

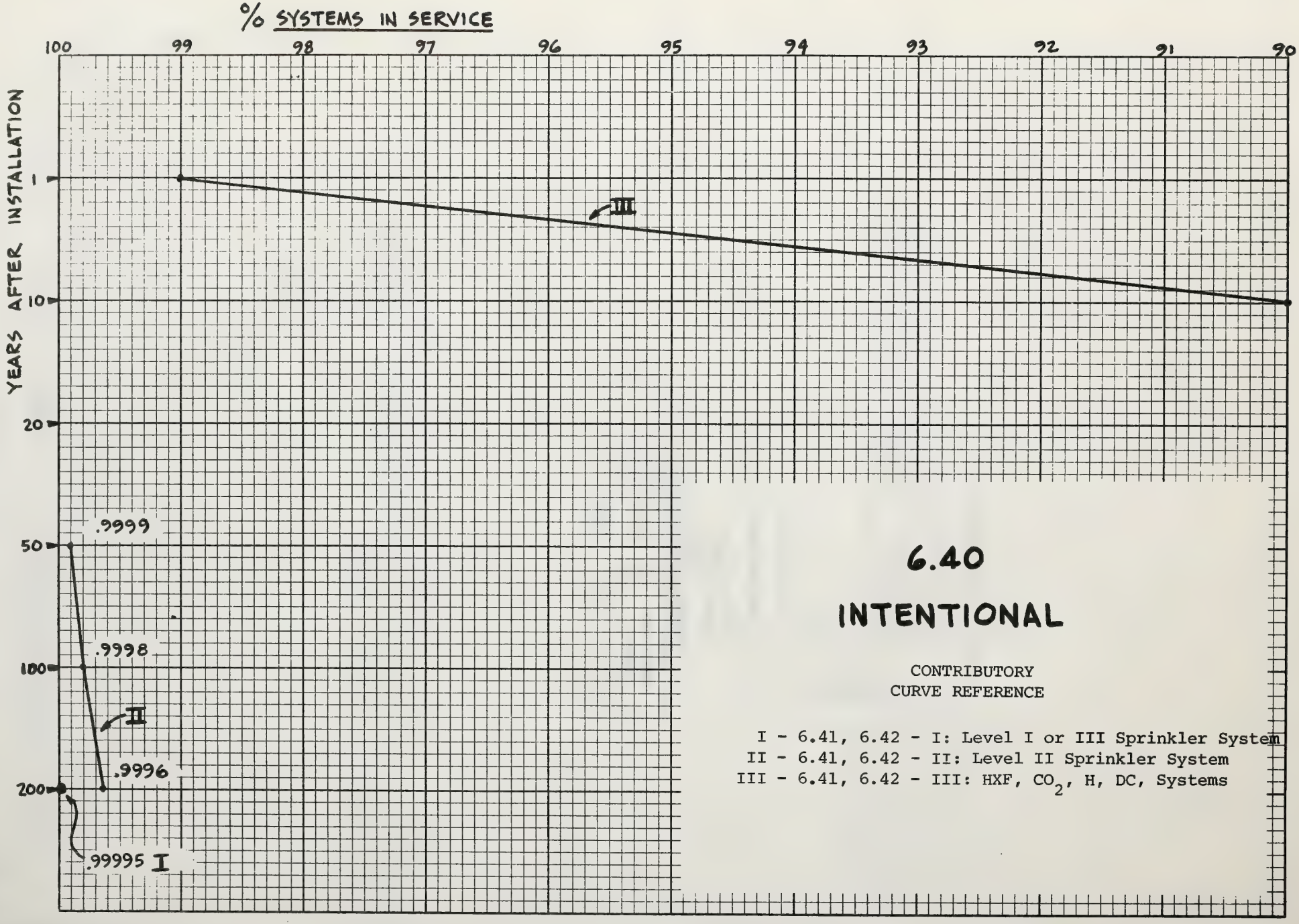
II - Water/Agent Supply, Electric Supply, Air Pressure

III-2.61 - Chart 6.40 - Intentional

III-2.61.1 Chart 6.40 shows the percent of systems which will be operable as a function of time after installation and false actuation frequency. The graphs are the product of the shut off rate and the false actuation rate combined through an "AND" gate.



III-2.61.2 Curve I represents a Level I or Level III sprinkler system, Curve II represents a Level II system and Curve III represents high expansion foam, carbon dioxide, Halon and dry chemical systems.



6.40

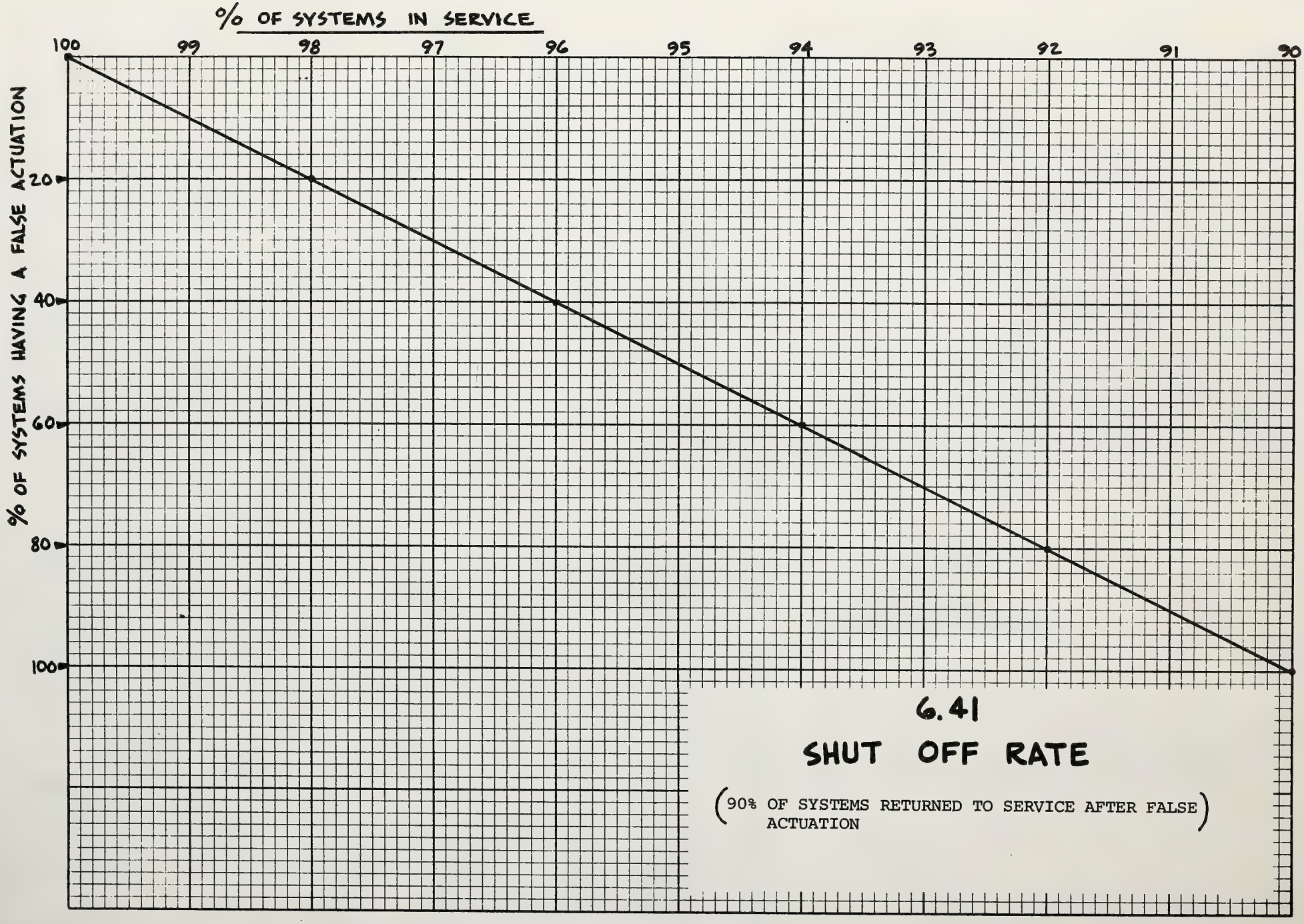
INTENTIONAL

CONTRIBUTORY
CURVE REFERENCE

I - 6.41, 6.42 - I: Level I or III Sprinkler System
II - 6.41, 6.42 - II: Level II Sprinkler System
III - 6.41, 6.42 - III: HXF, CO_2, H, DC, Systems

III-2.62 - Chart 6.41 - Shut Off Rate

Chart 6.41 shows the percent of systems which will be returned to service after false actuation. The curve was developed based upon information obtained through personal interviews with potential users throughout the country (3-4.6).



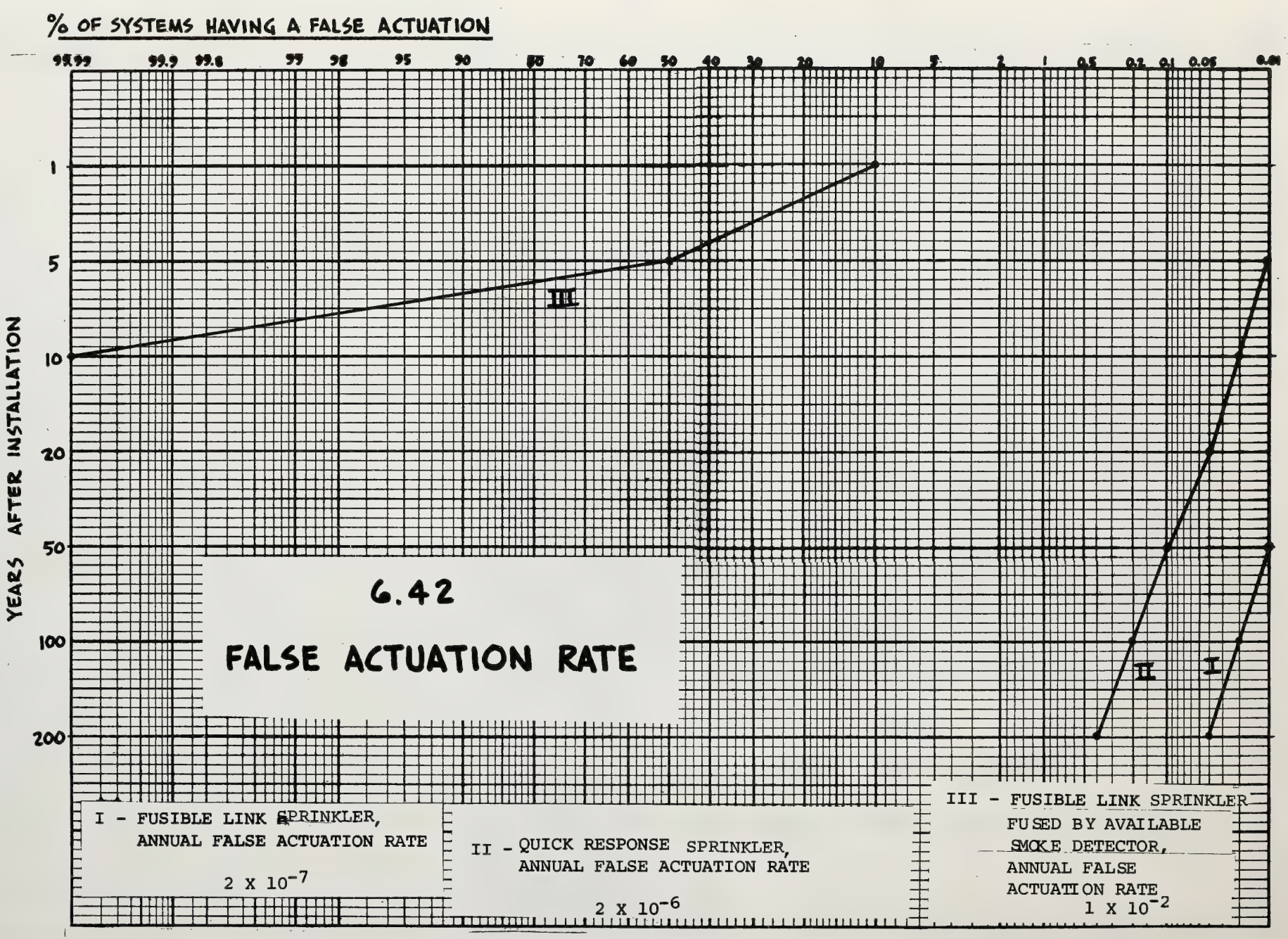
6.41

SHUT OFF RATE

(90% OF SYSTEMS RETURNED TO SERVICE AFTER FALSE ACTUATION)

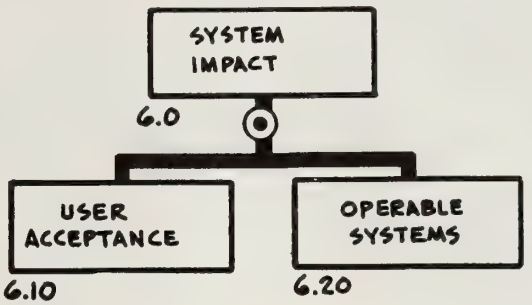
III-2.63 - Chart 6.42 - False Actuation Rate

Chart 6.42 shows the percent of systems which will have a false actuation as a function of time after installation and type of detector. The curves were developed using known false actuation experience for fusible link sprinklers, estimated false actuation frequency for quick response sprinklers and estimated false actuation frequency for smoke detectors. For this analysis, each system is considered to have 10 detectors, each of which could cause a false actuation if the detector were to activate.


% OF SYSTEMS HAVING A FALSE ACTUATION
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
YEARS AFTER INSTALLATION
1
5
10
20
50
100
200
III
II
I
6.42
FALSE ACTUATION RATE
I - FUSIBLE LINK SPRINKLER, ANNUAL FALSE ACTUATION RATE 2 X 10-7
II - QUICK RESPONSE SPRINKLER, ANNUAL FALSE ACTUATION RATE 2 X 10-6
III - FUSIBLE LINK SPRINKLER FUSED BY AVAILABLE SMOKE DETECTOR, ANNUAL FALSE ACTUATION RATE 1 X 10-2

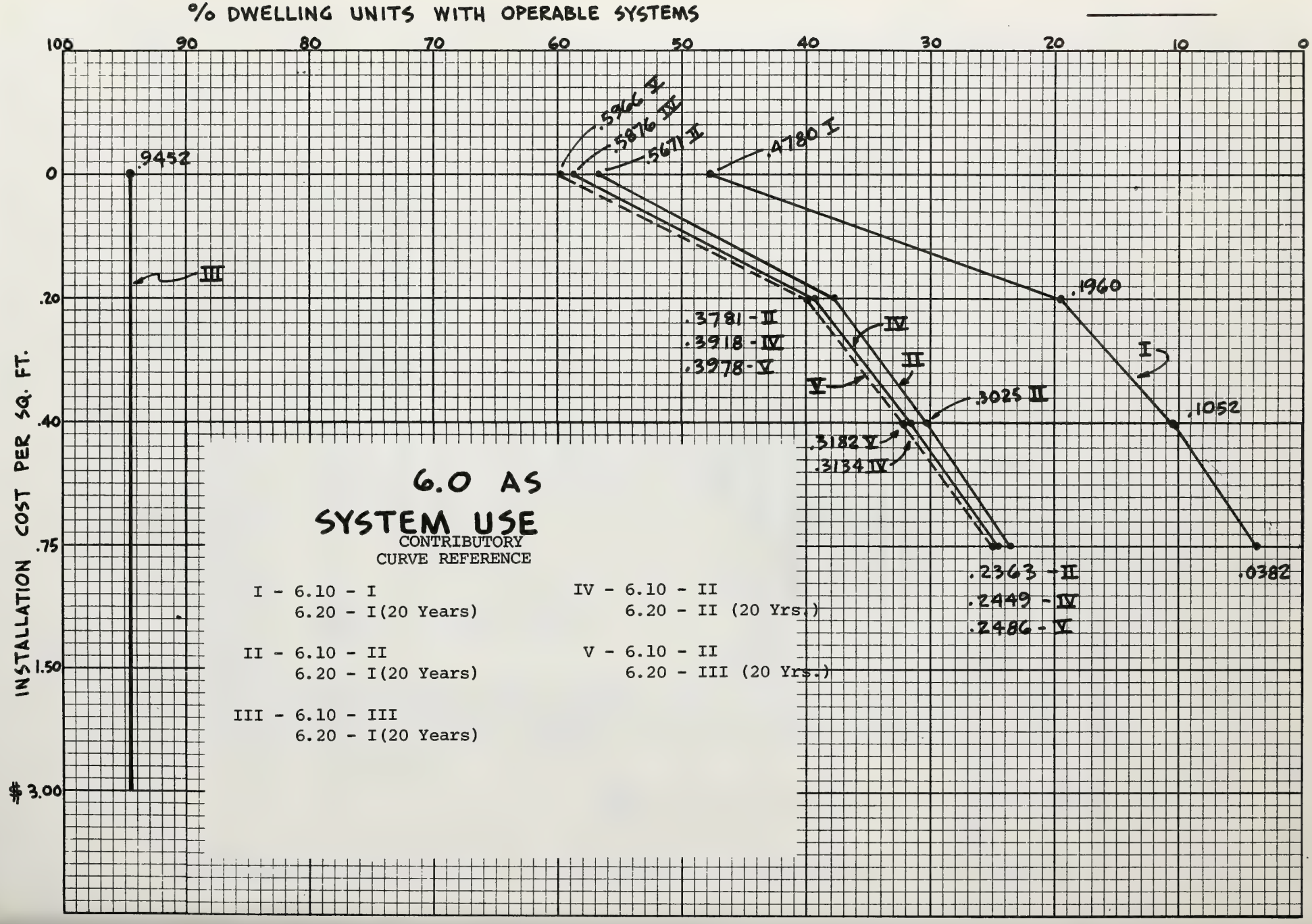
III-2.64 - Chart 6.0-AS System Use

III-2.64.1 Chart 6.0-AS shows the potential use of operable automatic suppression systems. It is expressed as the percent of dwelling units protected with an operable system as a function of the system installation cost. The curves are the product of the user acceptance and operable systems combined through an "AND" gate.



III-2.64.2

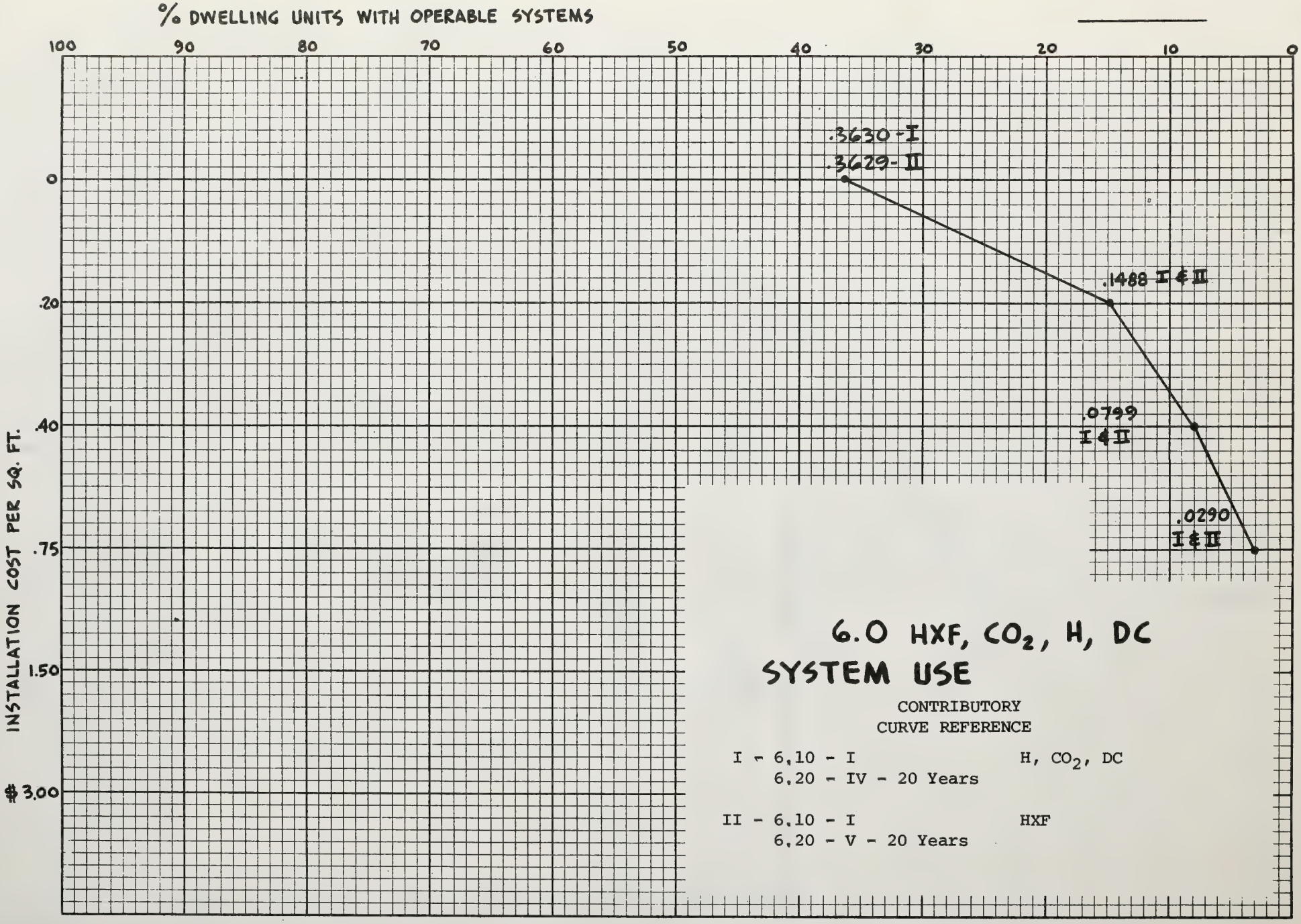
- Curve I represents voluntary acceptance of a Level I system;
- Curve II - Level I systems required in all new residential units;
- Curve III - 100% use of Level I systems;
- Curve IV - Level II systems required in all new residential units;
- Curve V - Level III systems required in all new residential units.


% DWELLING UNITS WITH OPERABLE SYSTEMS
100
90
80
70
60
50
40
30
20
10
0
INSTALLATION COST PER SQ. FT.
0
.20
.40
.75
1.50
$ 3.00
.9452
III
.5966 IV
.5876 V
.5671 II
.4780 I
.1960
I
.1052
.0382
.3781 - II
.3918 - IV
.3978 - V
IV
II
V
.3025 II
.3182 V
.3134 IV
.2363 - II
.2449 - IV
.2486 - V
6.0 AS
SYSTEM USE
CONTRIBUTORY
CURVE REFERENCE
I - 6.10 - I
6.20 - I(20 Years)
II - 6.10 - II
6.20 - I(20 Years)
III - 6.10 - III
6.20 - I(20 Years)
IV - 6.10 - II
6.20 - II (20 Yrs.)
V - 6.10 - II
6.20 - III (20 Yrs.)

III-2.65 - Chart 6.0 - HXF, CO2, H, DC System Impact

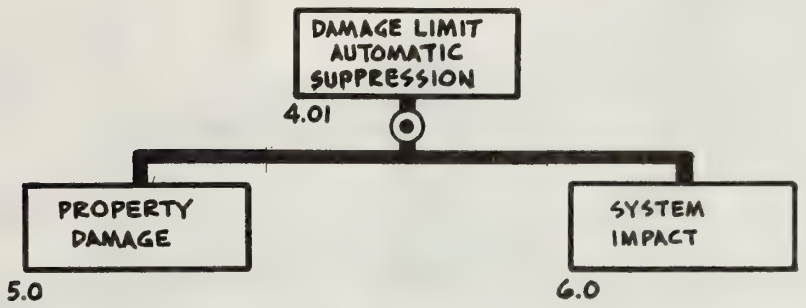
III-2.65.1 The impact of the four referenced systems is expressed as a function of the installation cost. The curve is developed in the same fashion as the curve on Chart 6.0 AS.

III-2.65.2 The installation cost of these systems exceeds $2.00/sq. ft. Because this cost is unacceptable to the public, these systems will not be widely used (3-4.2).


% DWELLING UNITS WITH OPERABLE SYSTEMS
100
90
80
70
60
50
40
30
20
10
0
INSTALLATION COST PER SQ. FT.
0
.20
.40
.75
1.50
$3.00
.3630 - I
.3629 - II
.1488 I & II
.0799 I & II
.0290 I & II
6.0 HXF, CO_2, H, DC
SYSTEM USE
CONTRIBUTORY
CURVE REFERENCE
I - 6.10 - I
6.20 - IV - 20 Years
H, CO_2, DC
II - 6.10 - I
6.20 - V - 20 Years
HXF

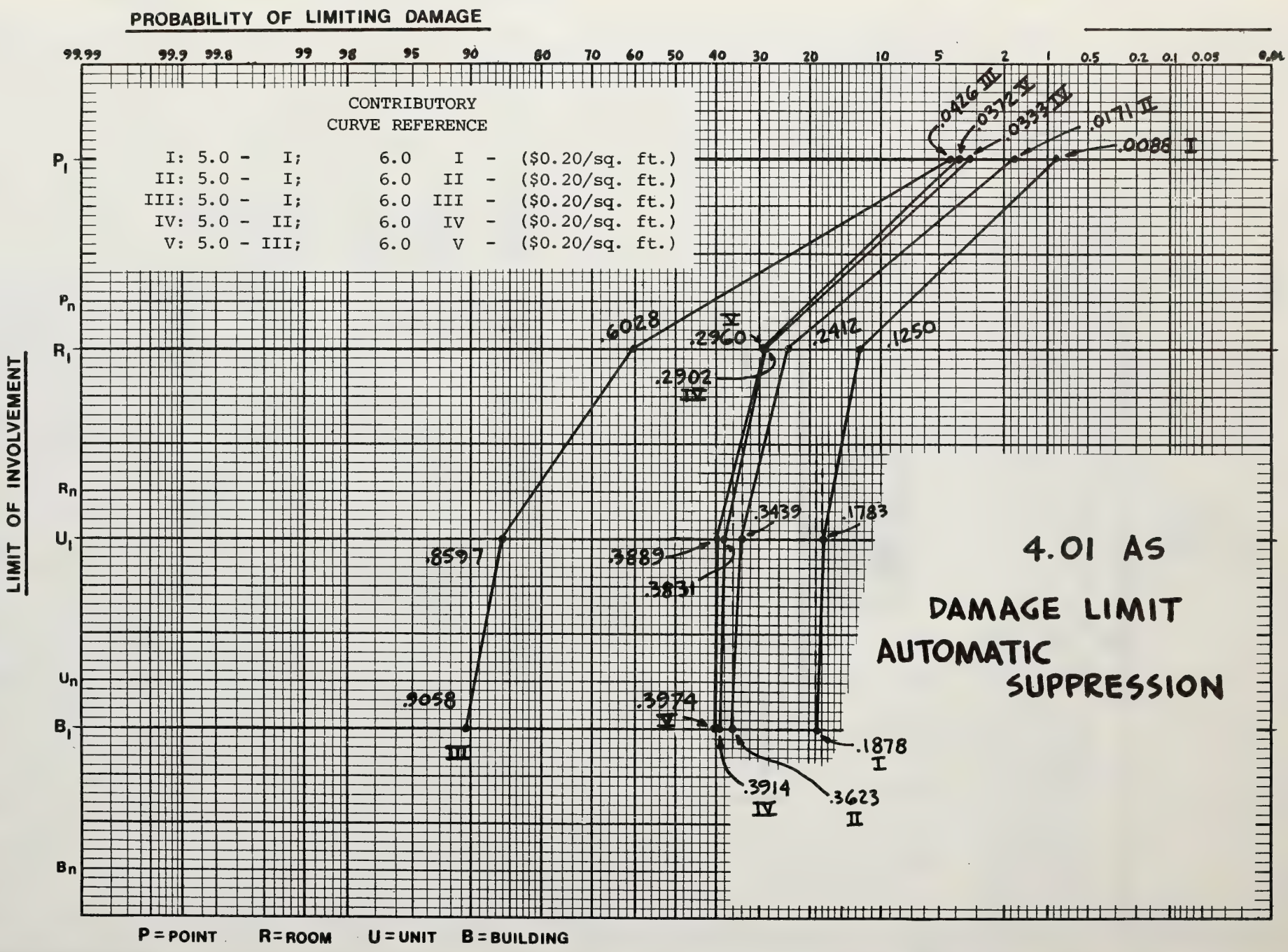
III-2.66 - Chart 4.01-AS Damage Limit Automatic Suppression

III-2.66.1 Chart 4.01-AS expresses the ability of automatic sprinkler systems to limit damage on a national basis. It is the product of the ability of a system to-limit property damage and the percent of dwelling units which have operable systems combined through an "AND" gate.



III-2.66.2

- Curve I represents the voluntary use of a Level I system available at the target cost of $0.20/sq. ft.
- Curve II represents the use of a Level I system which is required by law in all new residential units and available at a cost of $0.20/sq. ft.
- Curve III represents the use of a Level I system installed in all residential units.
- Curve IV represents the use of a Level II system which is required to be installed in all new residential units and available at a cost of $0.20/sq. ft.
- Curve V represents the use of a Level III system which is also required to be installed in all new residential units and available at a cost of $0.20/ sq. ft.

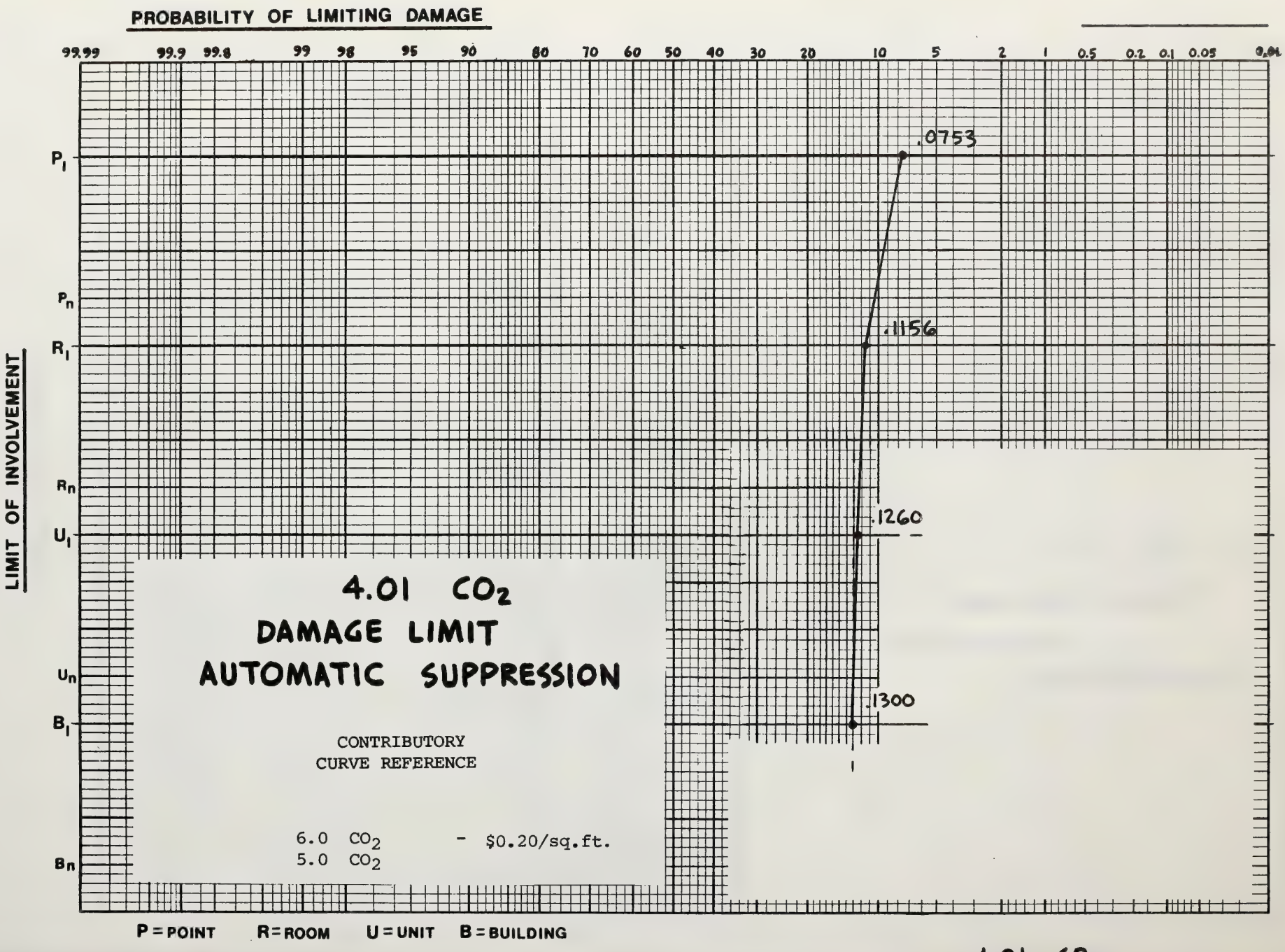

PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
CONTRIBUTORY
CURVE REFERENCE
I: 5.0 - I; 6.0 I - ($0.20/sq. ft.)
II: 5.0 - I; 6.0 II - ($0.20/sq. ft.)
III: 5.0 - I; 6.0 III - ($0.20/sq. ft.)
IV: 5.0 - II; 6.0 IV - ($0.20/sq. ft.)
V: 5.0 - III; 6.0 V - ($0.20/sq. ft.)
.0426 III
.0372 V
.0333 IV
.0171 II
.0088 I
.6028
.2960 V
.2902 IV
.2412
.1250
.8597
.3889
.3831
.3439
.1783
.9058 III
.3974 V
.1878 I
.3914 IV
.3623 II
4.01 AS
DAMAGE LIMIT
AUTOMATIC
SUPPRESSION
P = POINT R = ROOM U = UNIT B = BUILDING

4.01 AS

III-2.67 - Chart 4.01 - CO2 Damage Limit Automatic Suppression

III-2-67.1 Chart 4.01 - CO2 shows the influence of carbon dioxide systems in limiting damage on a national basis (assuming they can be made cost competitive with sprinkler systems). The carbon dioxide systems are comparable to the sprinkler systems in this respect and will be considered for further study.

III-2.67.2 The curve on this chart was developed in the same fashion as the curves on Chart 4.01 AS.

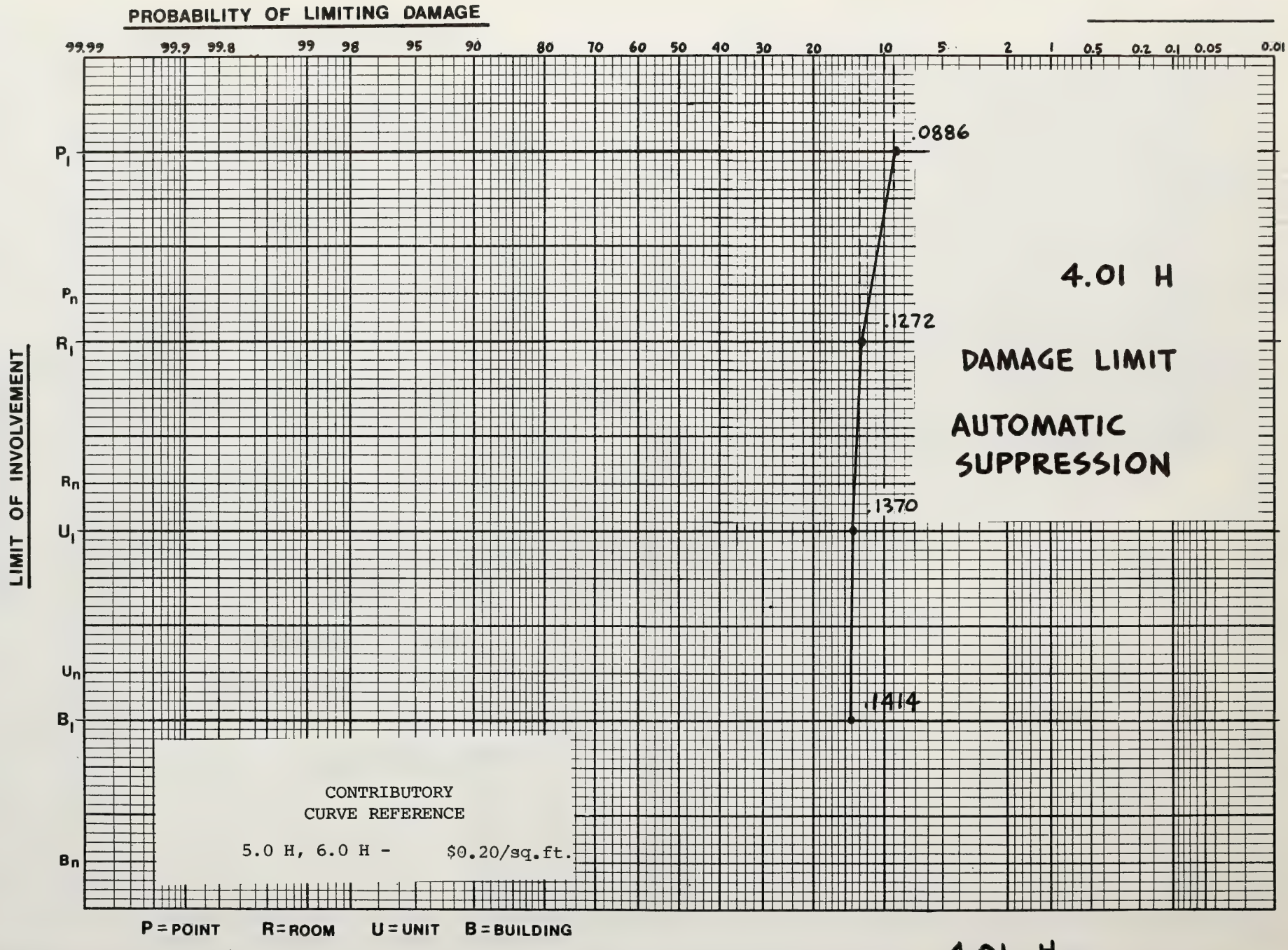

PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0753
.1156
.1260
.1300
4.01 CO2
DAMAGE LIMIT
AUTOMATIC SUPPRESSION
CONTRIBUTORY
CURVE REFERENCE
6.0 CO2 - $0.20/sq.ft.
5.0 CO2
P = POINT R = ROOM U = UNIT B = BUILDING

4.01 CO_2

III-2.68 - Chart 4.01 - H Damage Limit Automatic Suppression

III-2.68.1 Chart 4.01 - H shows that Halon systems are also comparable to the sprinkler system in this respect (assuming they can be made cost competitive with sprinkler systems). They will be considered for further study.

III-2.68.2 The curve on this chart was developed in the same fashion as the curves on Chart 4.01 AS.

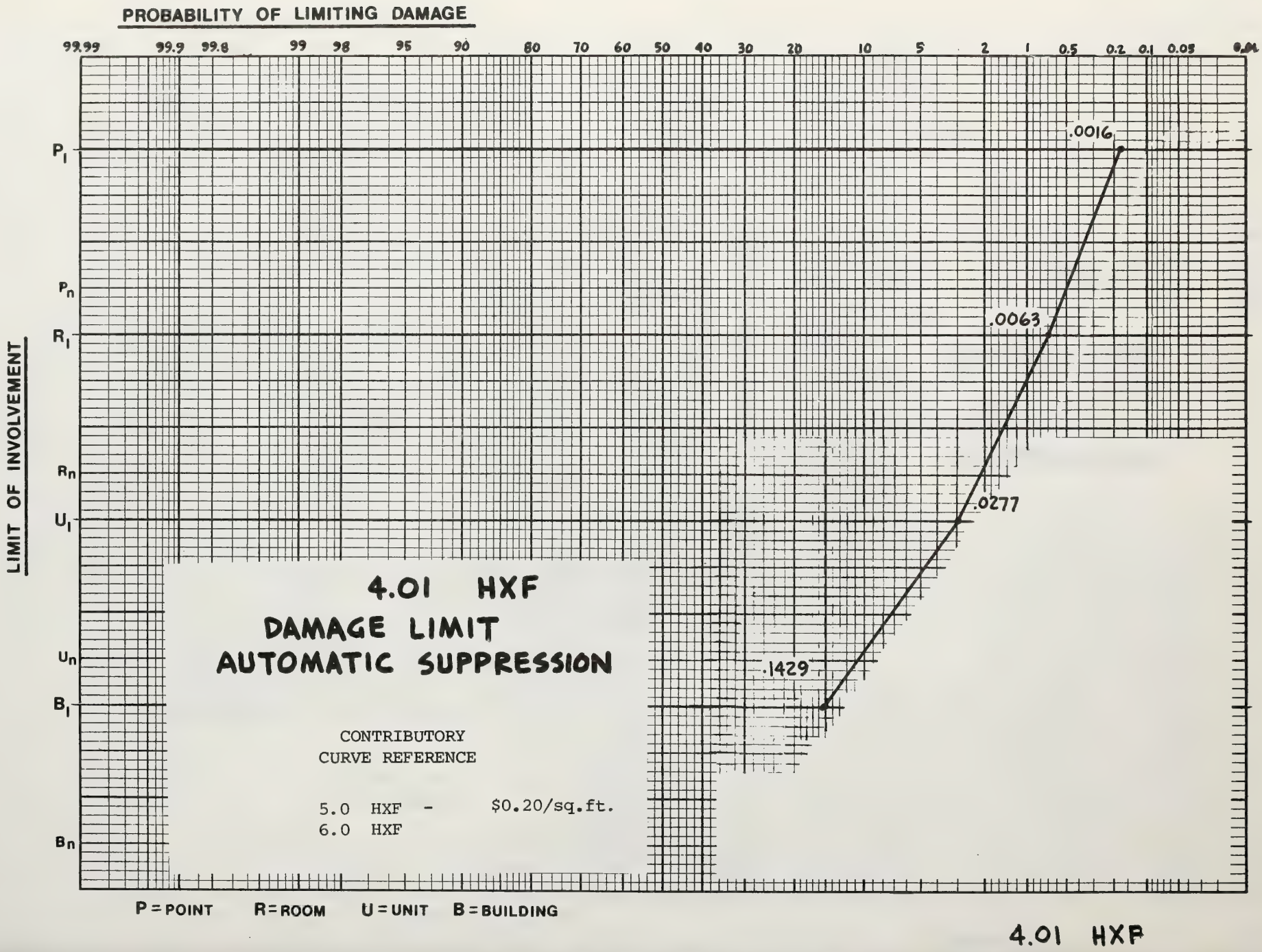

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0886
.1272
.1370
.1414
4.01 H
DAMAGE LIMIT
AUTOMATIC
SUPPRESSION
CONTRIBUTORY
CURVE REFERENCE
5.0 H, 6.0 H - $0.20/sq.ft.
P = POINT R = ROOM U = UNIT B = BUILDING

4.01 H

III-2.69 - Chart 4.01-HXF Damage Limit Automatic Suppression

III-2.69.1 Chart 4.01-HXF shows that high expansion foam systems have a lesser ability to limit damage on a national basis than do the sprinkler systems, even if they can be made cost competitive. On the basis of this analysis, high expansion foam systems are considered to be unacceptable for use in residential occupancies.

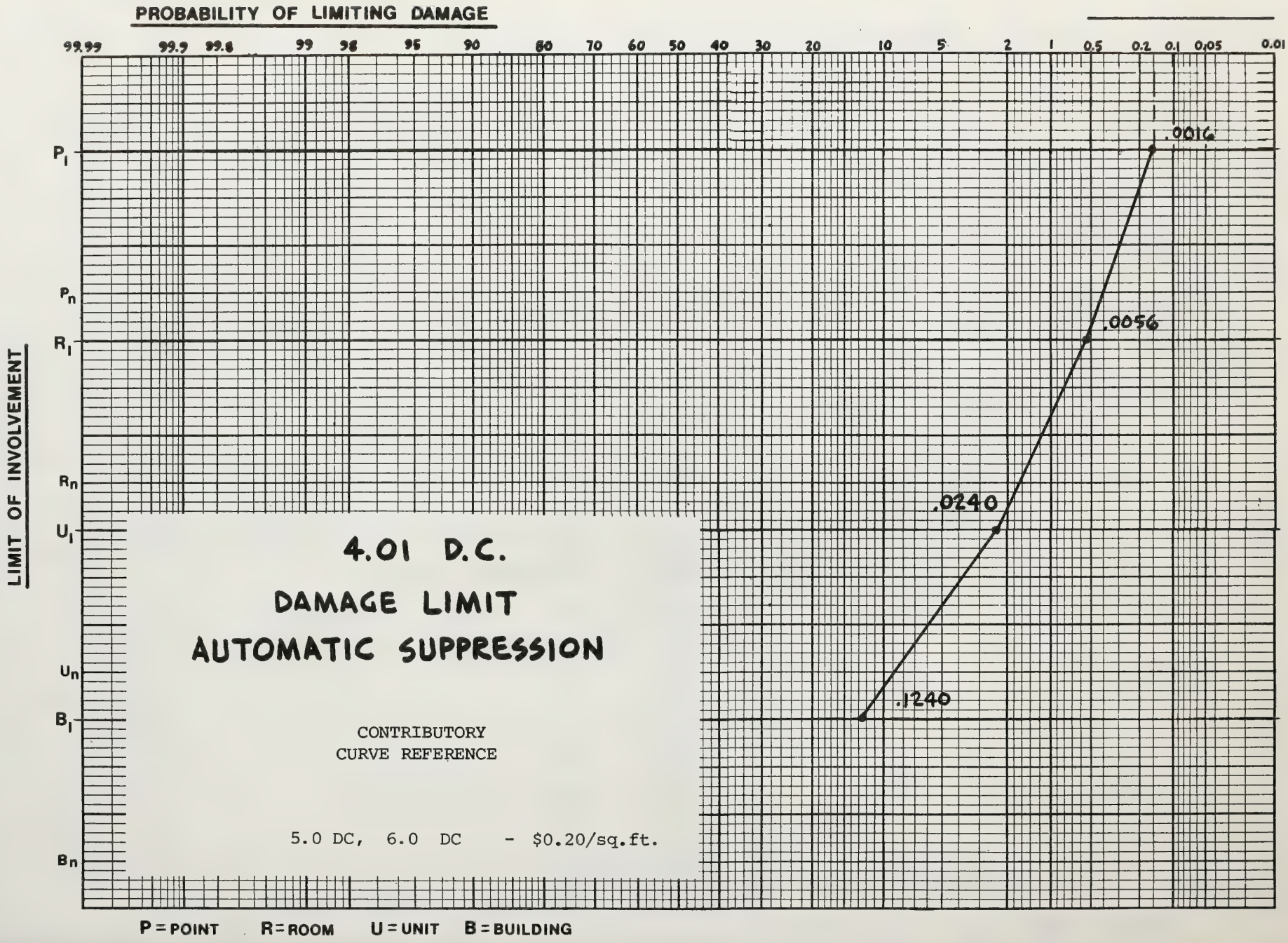
III-2.69.2 The curve on this chart was developed in the same fashion as the curves on Chart 4.01 AS.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0016
.0063
.0277
.1429
4.01 HXF
DAMAGE LIMIT
AUTOMATIC SUPPRESSION
CONTRIBUTORY
CURVE REFERENCE
5.0 HXF - $0.20/sq.ft.
6.0 HXF
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.70 - Chart 4.01-DC Damage Limit Automatic Suppression

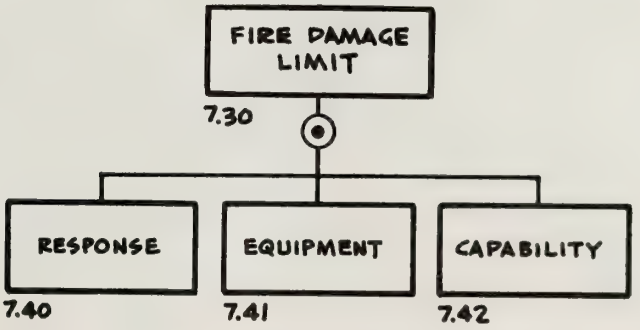
III-2.70.1 Chart 4.01 shows that dry chemical systems are less effective than sprinkler systems in limiting total damage on a national basis even if they can be made cost competitive. On the basis of this analysis, dry chemical systems are considered to be unacceptable for use in residential occupancies.

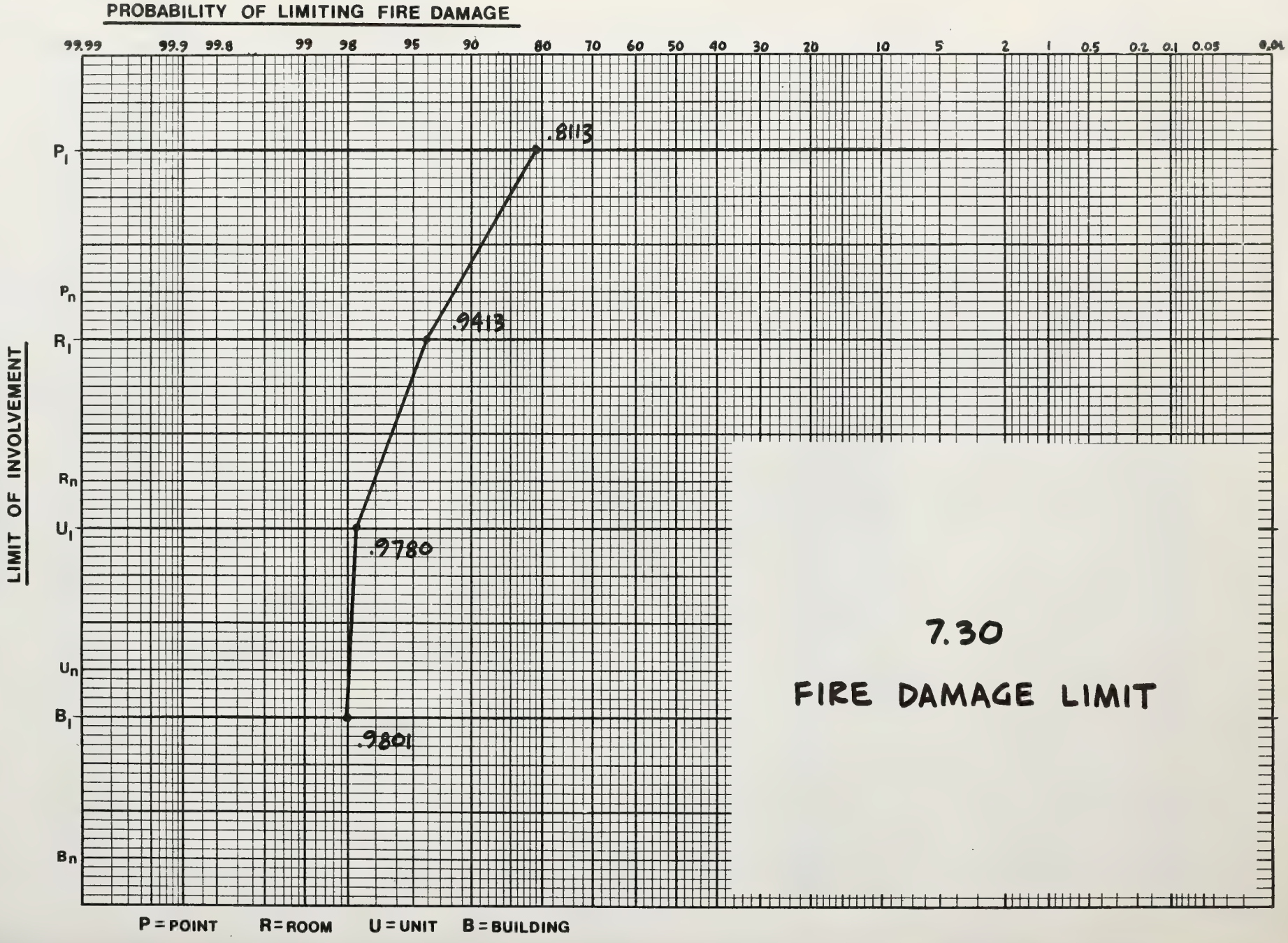
III-2.70.2 The curve on this chart was developed in the same fashion as the curves on Chart 4.01 AS.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0016
.0056
.0240
.1240
4.01 D.C.
DAMAGE LIMIT
AUTOMATIC SUPPRESSION
CONTRIBUTORY
CURVE REFERENCE
5.0 DC, 6.0 DC - $0.20/sq.ft.
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.71- Chart 7.30 - Fire Damage Limit

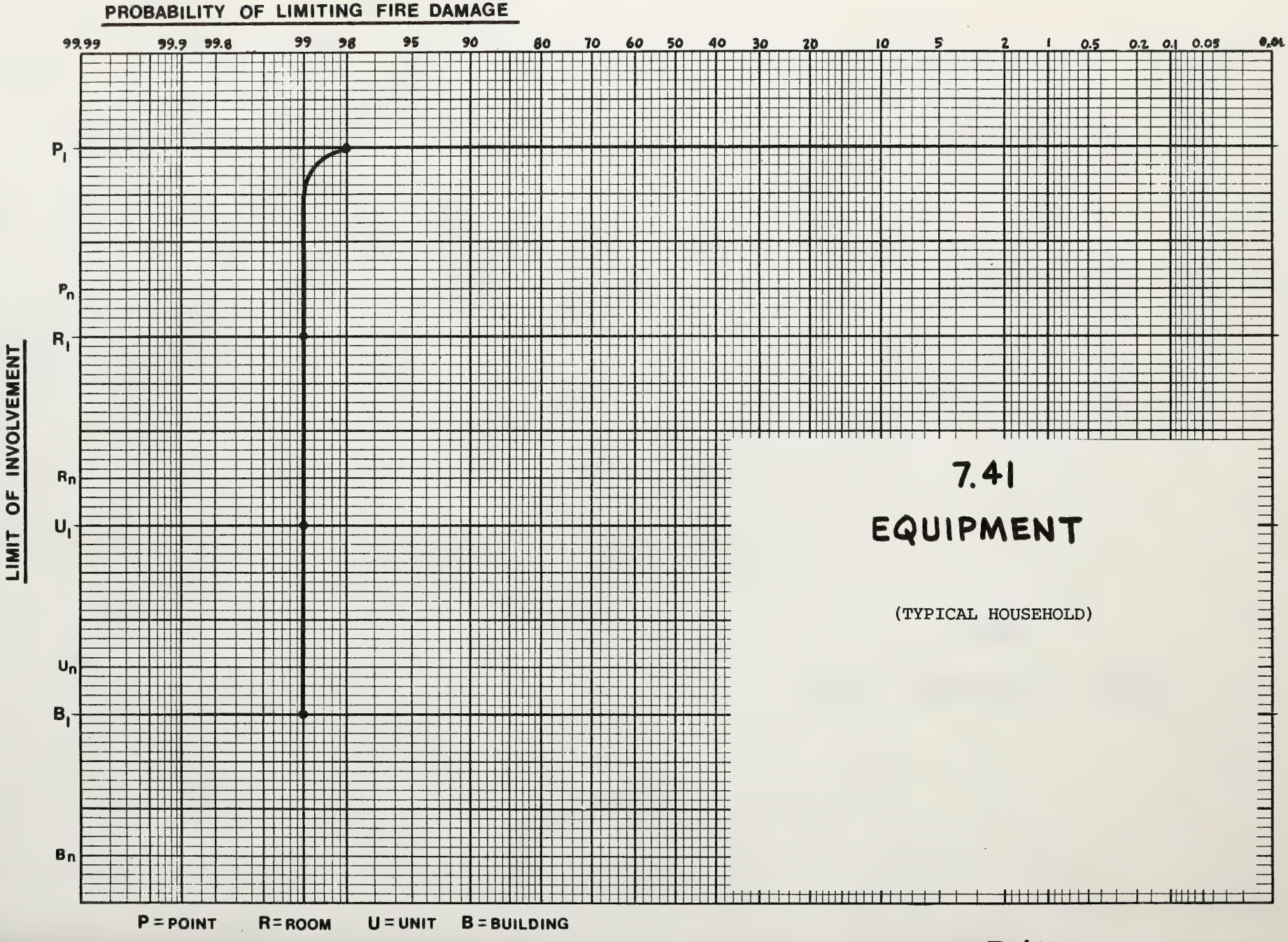
Chart 7.30 shows the ability of the occupant to limit fire damage. It is the product of response, equipment and capability combined through an "AND" gate.




PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.8113
.9413
.9780
.9801
7.30
FIRE DAMAGE LIMIT
P = POINT
R = ROOM
U = UNIT
B = BUILDING

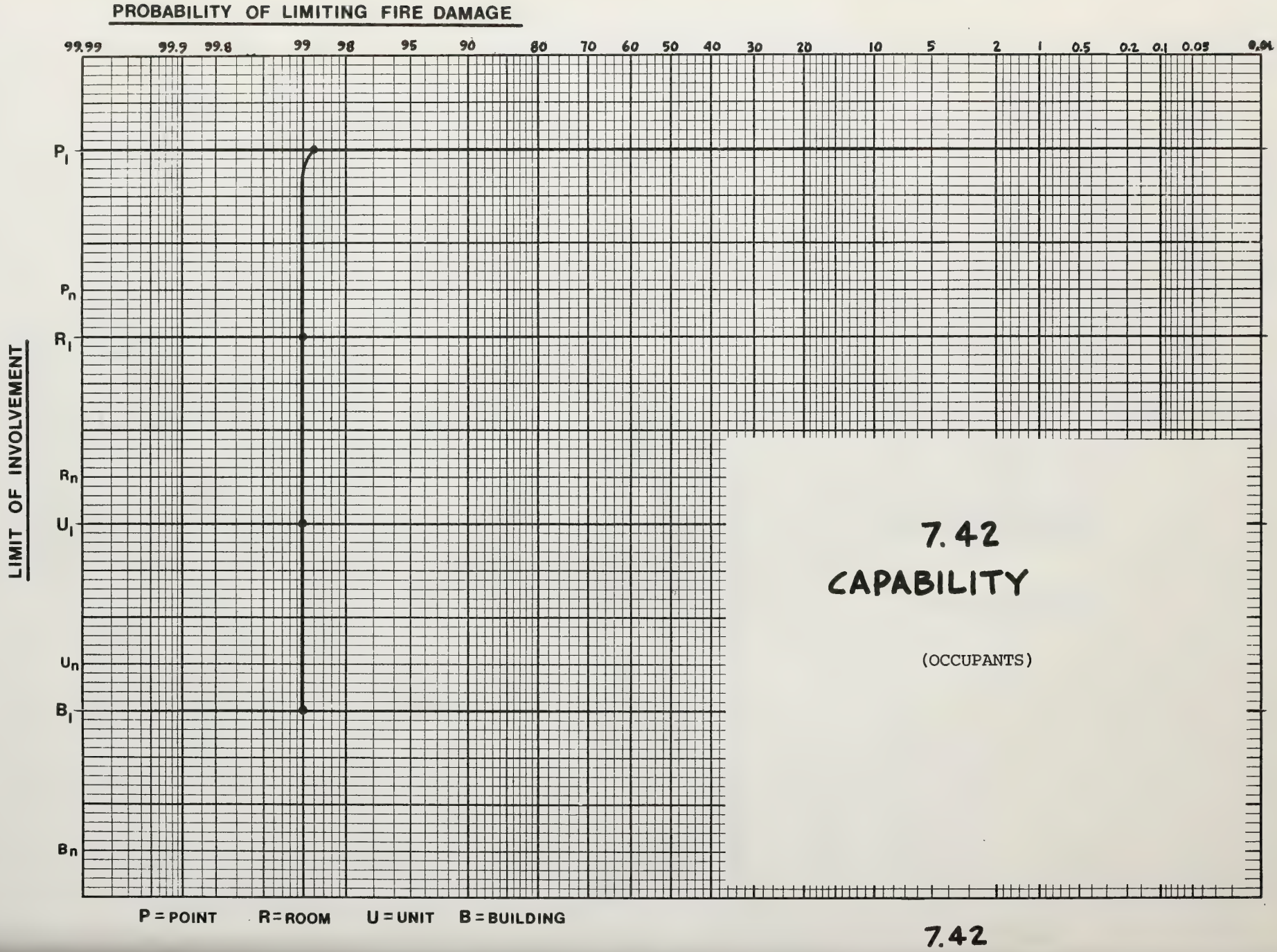
III-2.71 - Chart 7.41 - Equipment

Chart 7.41 shows the effect of fire fighting equipment on limiting fire damage. The curve is based on judgment considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
7.41
EQUIPMENT
(TYPICAL HOUSEHOLD)
P = POINT
R = ROOM
U = UNIT
B = BUILDING

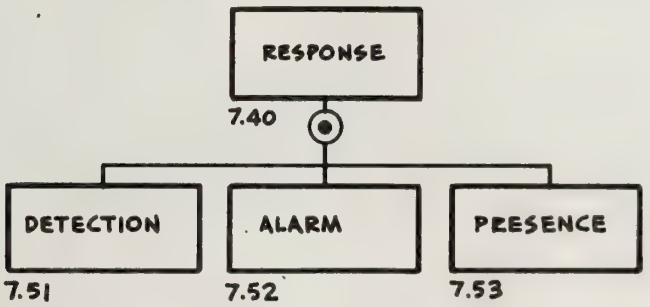
III-2.73 - Chart 7.42 - Capability

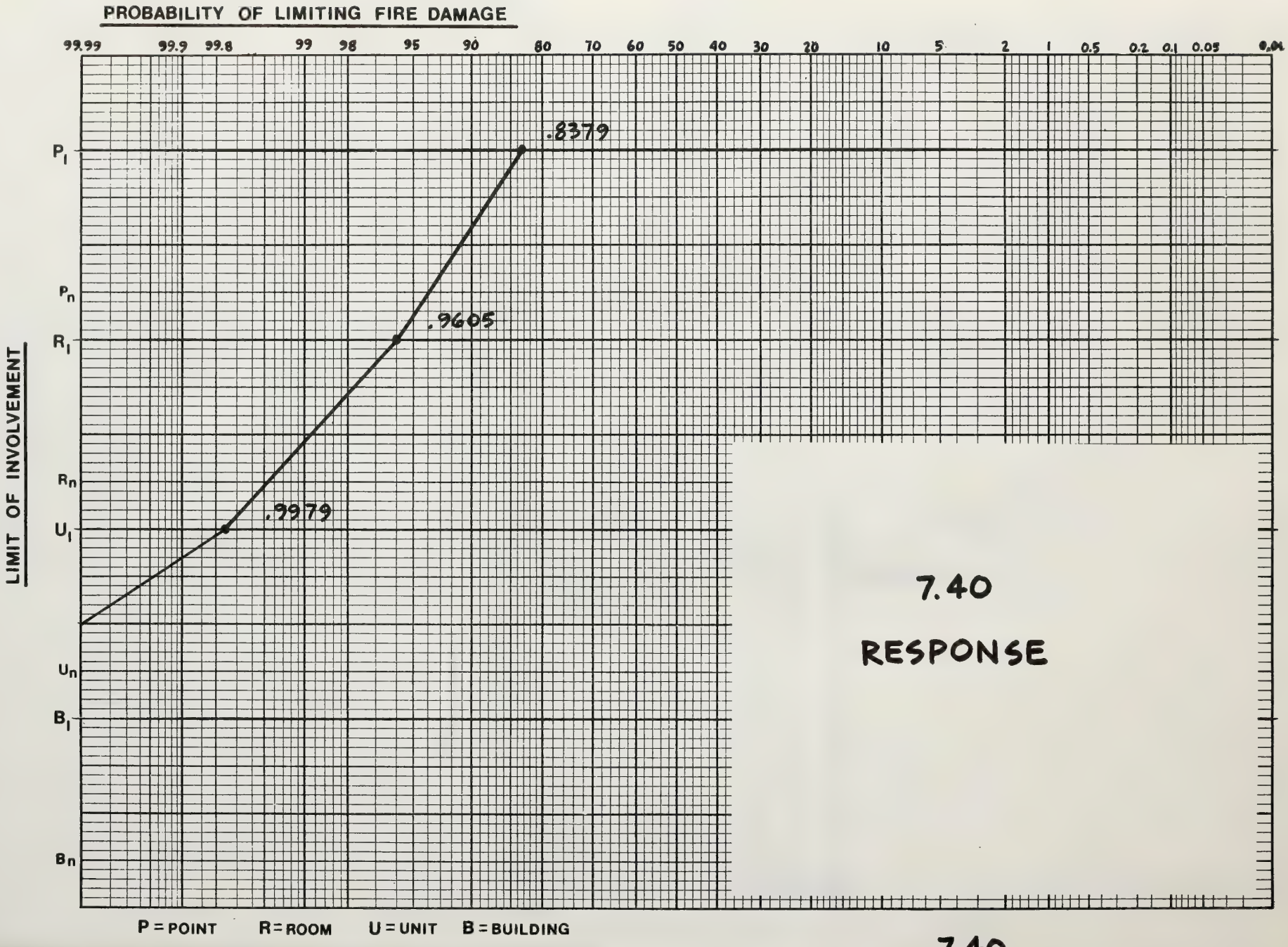
Chart 7.42 shows the ability of the occupants to limit fire damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.42
CAPABILITY
(OCCUPANTS)

III-2.74 - Chart 7.40 - Response

Chart 7.40 shows the effect of response in limiting fire damage. It is the product of fire detection, fire alarm and presence combined through an "AND" gate.

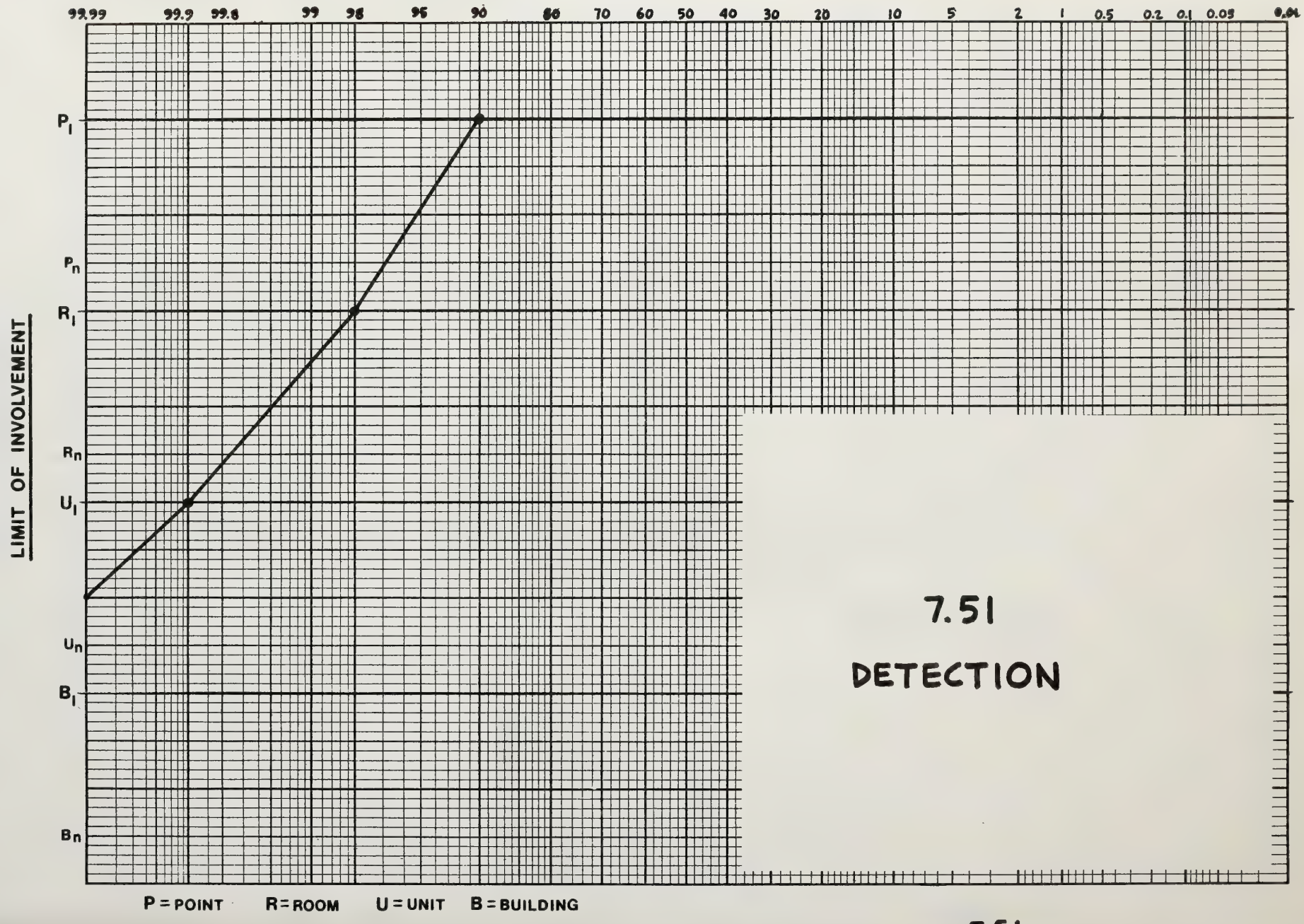



PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.8379
.9605
.9979
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.40
RESPONSE

III-2.75 - Chart 7.51 - Detection

III-2.75.1 Chart 7.51 shows the effect of fire detection in limiting fire damage. The curve is based on judgment, considering fire records.

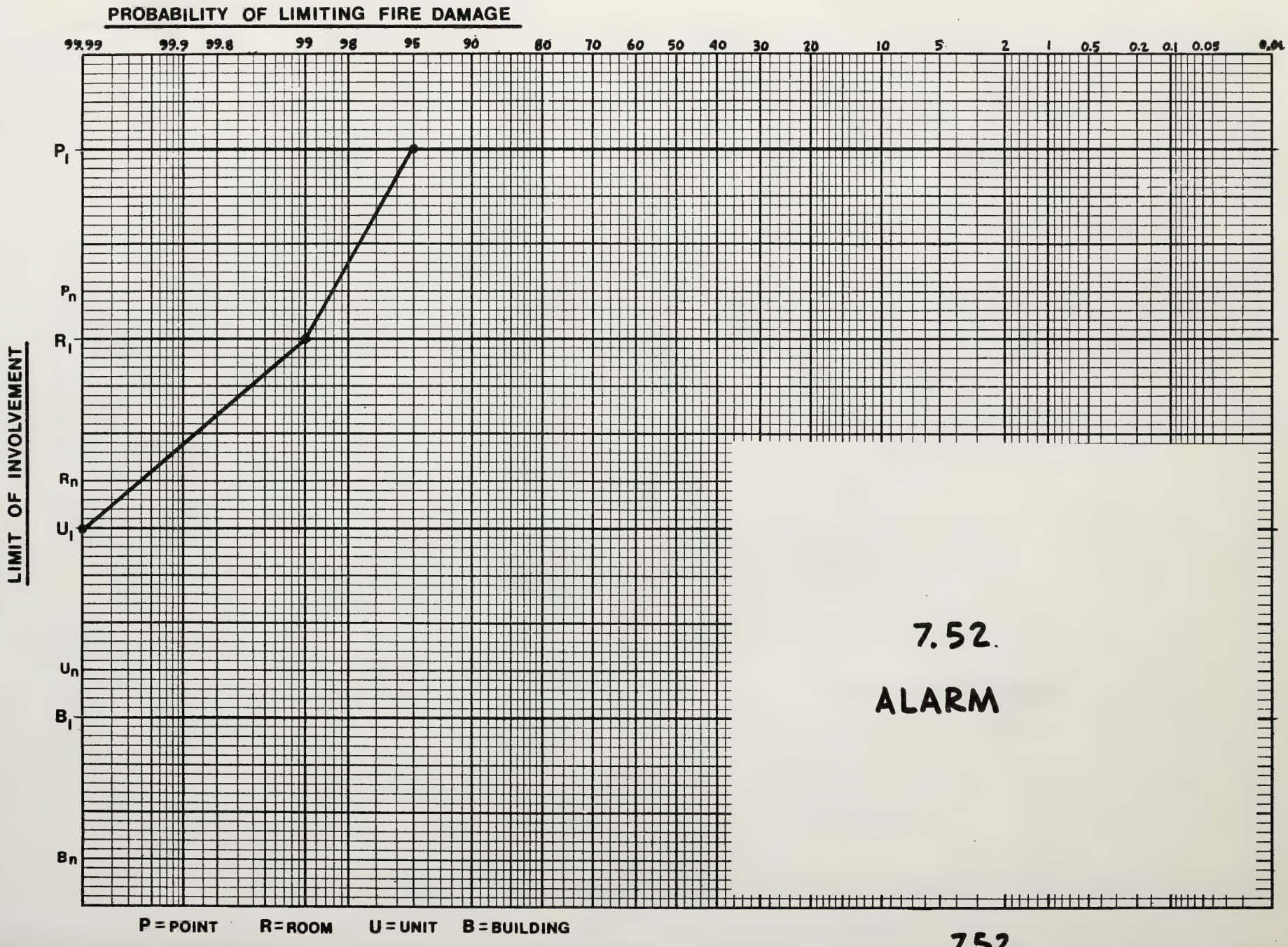
III-2.75.2 Detection is an important item which can have significant impact on the National Residential Fire Loss by improving manual fire fighting response. Investigation of this item is beyond the scope of this project.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.51
DETECTION

III-2.76 - Chart 7.52 - Alarm

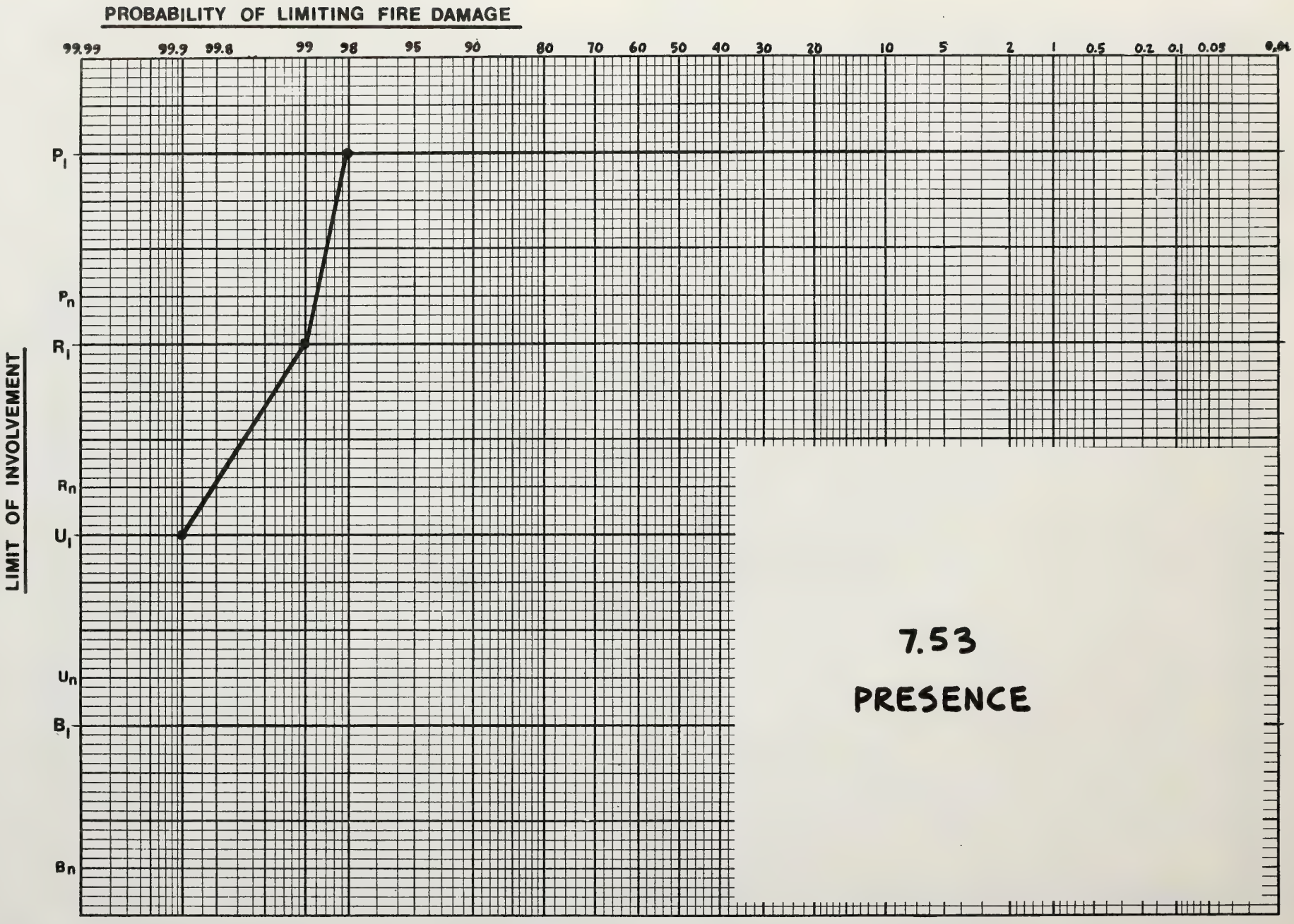
III-2.76.1 Chart 7.52 shows the effect of alarm transmission after fire is detected. The curve is based on judgment, considering fire records.

III-2.76.2 Alarm is an important contributory factor to manual fire fighting response. Presence of alarm devices may significantly alter the National Residential Fire Loss. Investigation of this item is beyond the scope of this project.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.52.
ALARM

III-2.77 - Chart 7.53 - Presence

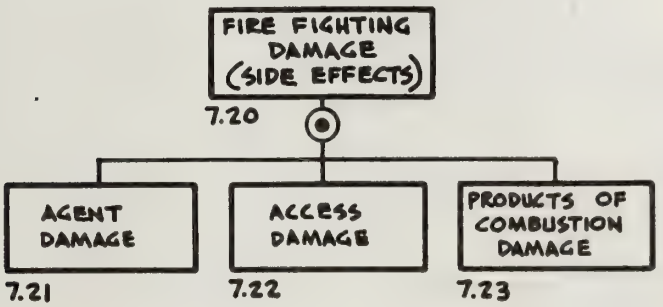
Chart 7.53 shows the effect of the presence of the occupant on limiting fire damage. The curve is based on judgment, considering fire records.

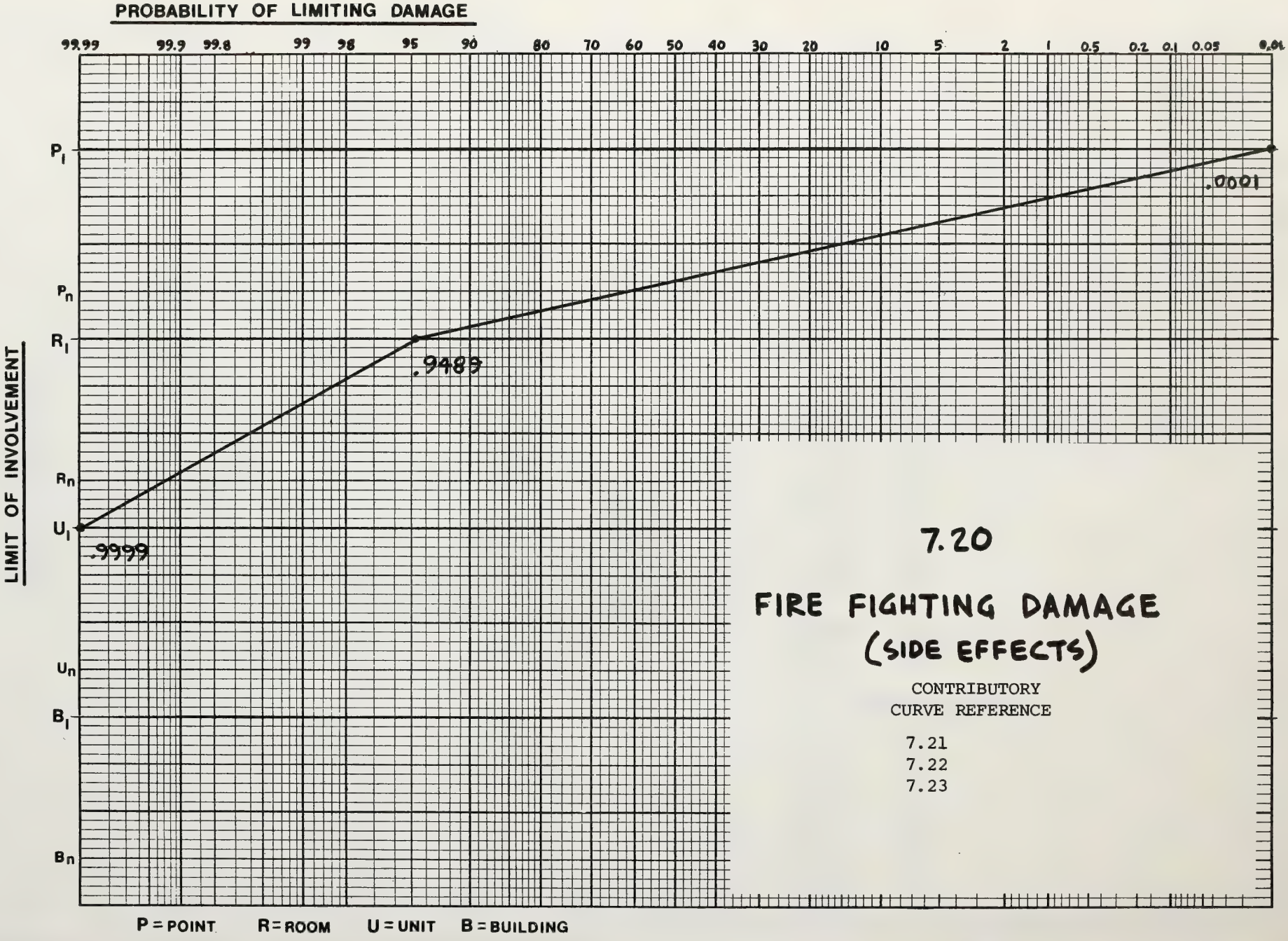

PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.53
PRESENCE

7.53

III-2.78 - Chart 7.20 - Fire Fighting Damage

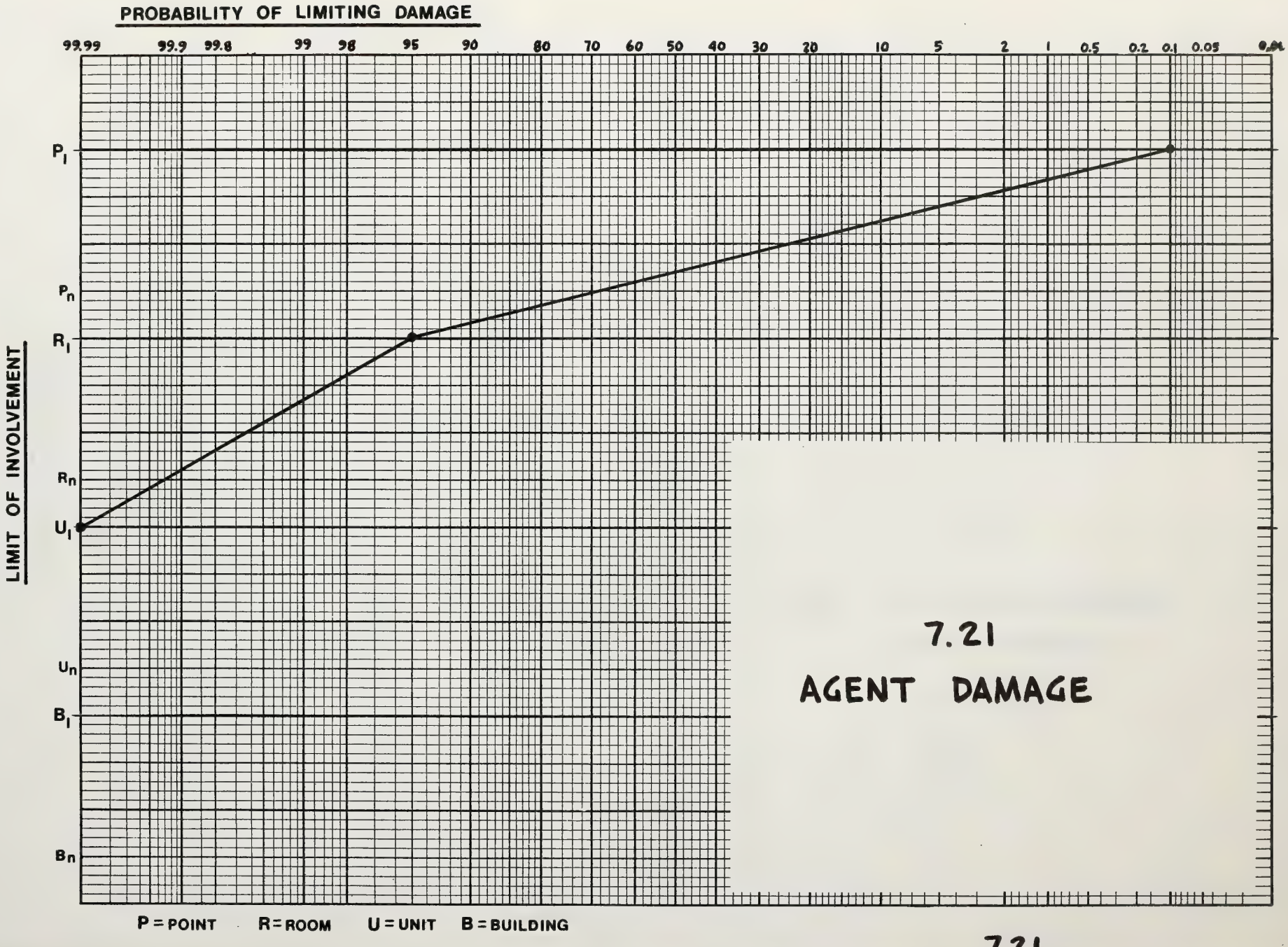
Chart 7.20 shows the damage caused by manual fire fighting. The curve was developed using the product of agent damage, access damage and products of combustion damage combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9999
.9489
.0001
7.20
FIRE FIGHTING DAMAGE
(SIDE EFFECTS)
CONTRIBUTORY
CURVE REFERENCE
7.21
7.22
7.23
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.79 - Chart 7.21 - Agent Damage

Chart 7.21 shows the ability of manual fire fighting to limit agent damage. The curve is based on judgment, considering fire records.

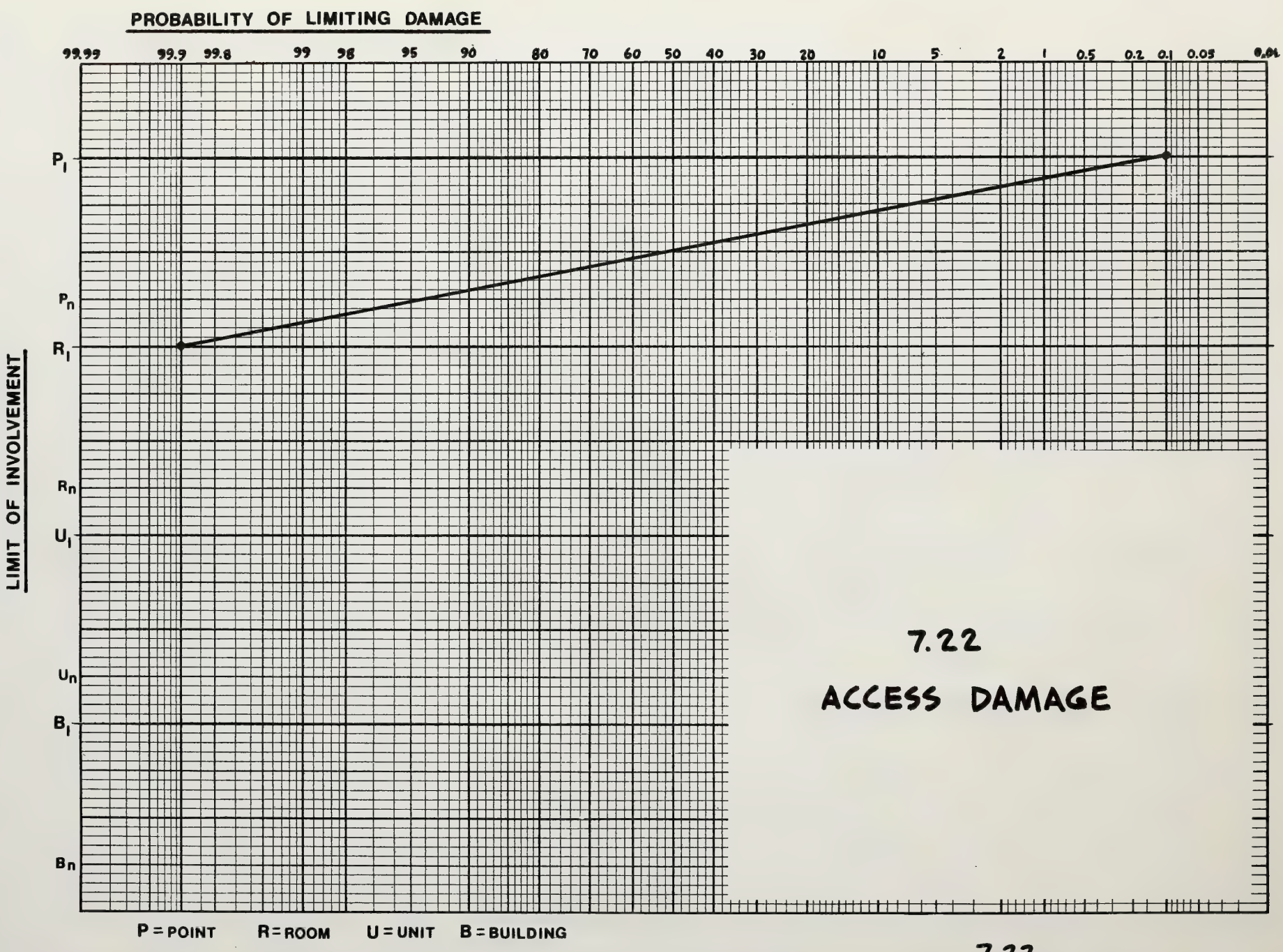


7.21

AGENT DAMAGE

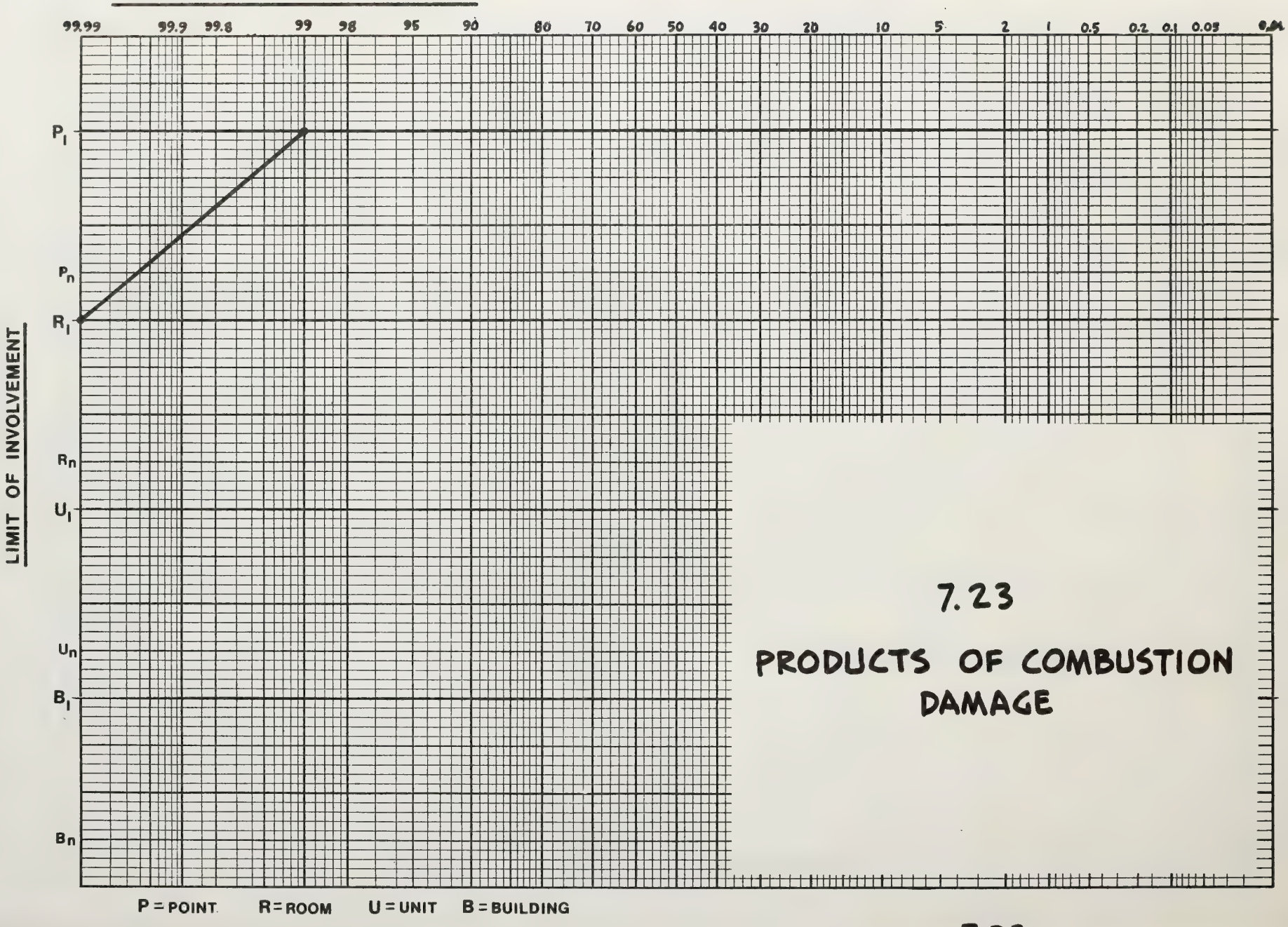
III-2.80 - Chart 7.22 - Access Damage

Chart 7.22 shows the ability of manual fire fighting to limit access damage (i.e. damage caused gaining access to the fire). The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_l
P_n
R_l
R_n
U_l
U_n
B_l
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.22
ACCESS DAMAGE

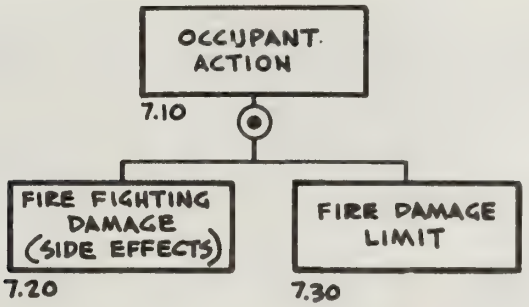
III-2.81 - Chart 7.23 - Products of Combustion Damage

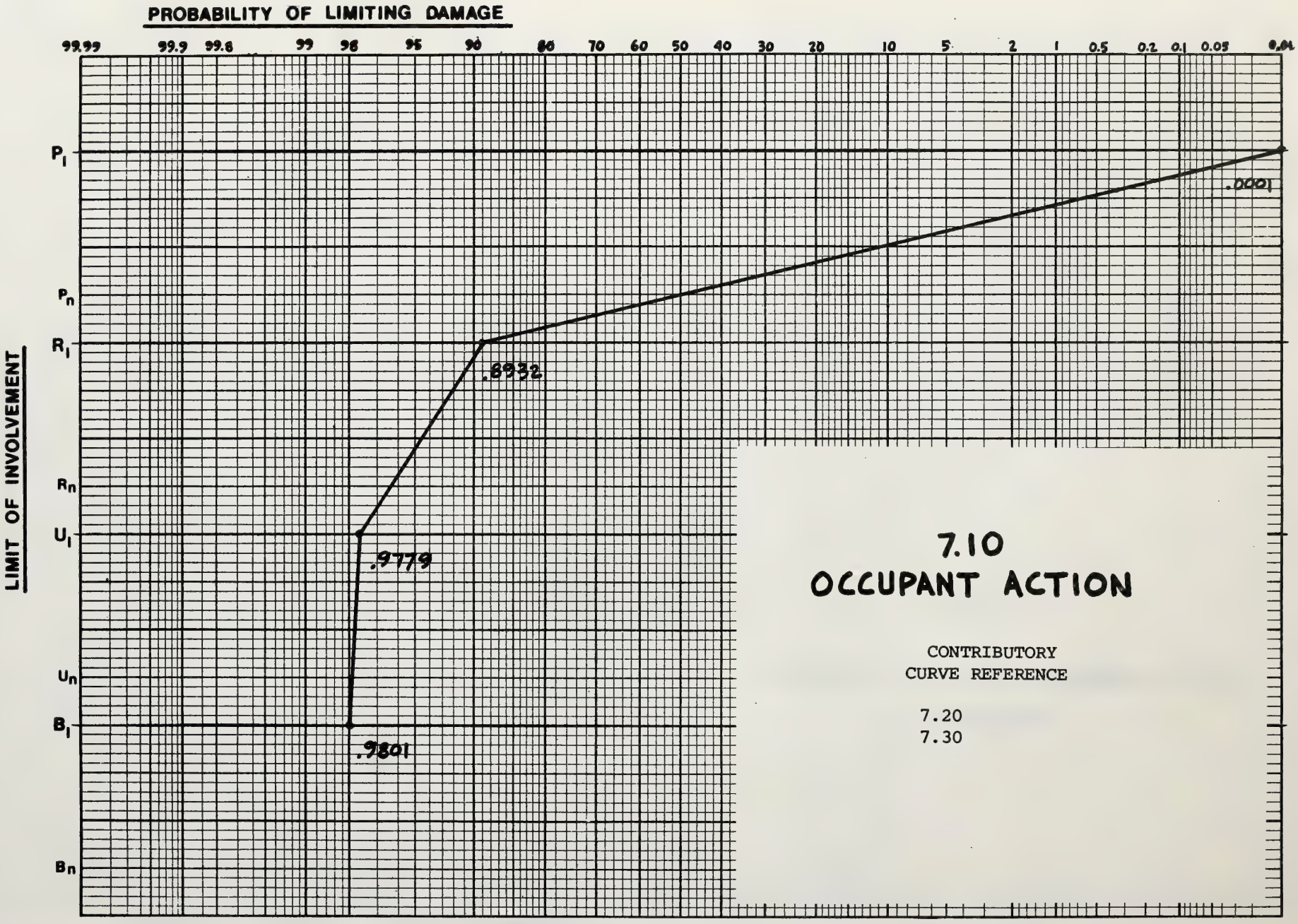
Chart 7.23 shows the ability of occupants to limit the increased products of combustion damage caused during the control/extinguishing process. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
7.23
PRODUCTS OF COMBUSTION DAMAGE
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.82 - Chart 7.10 - Occupant Action

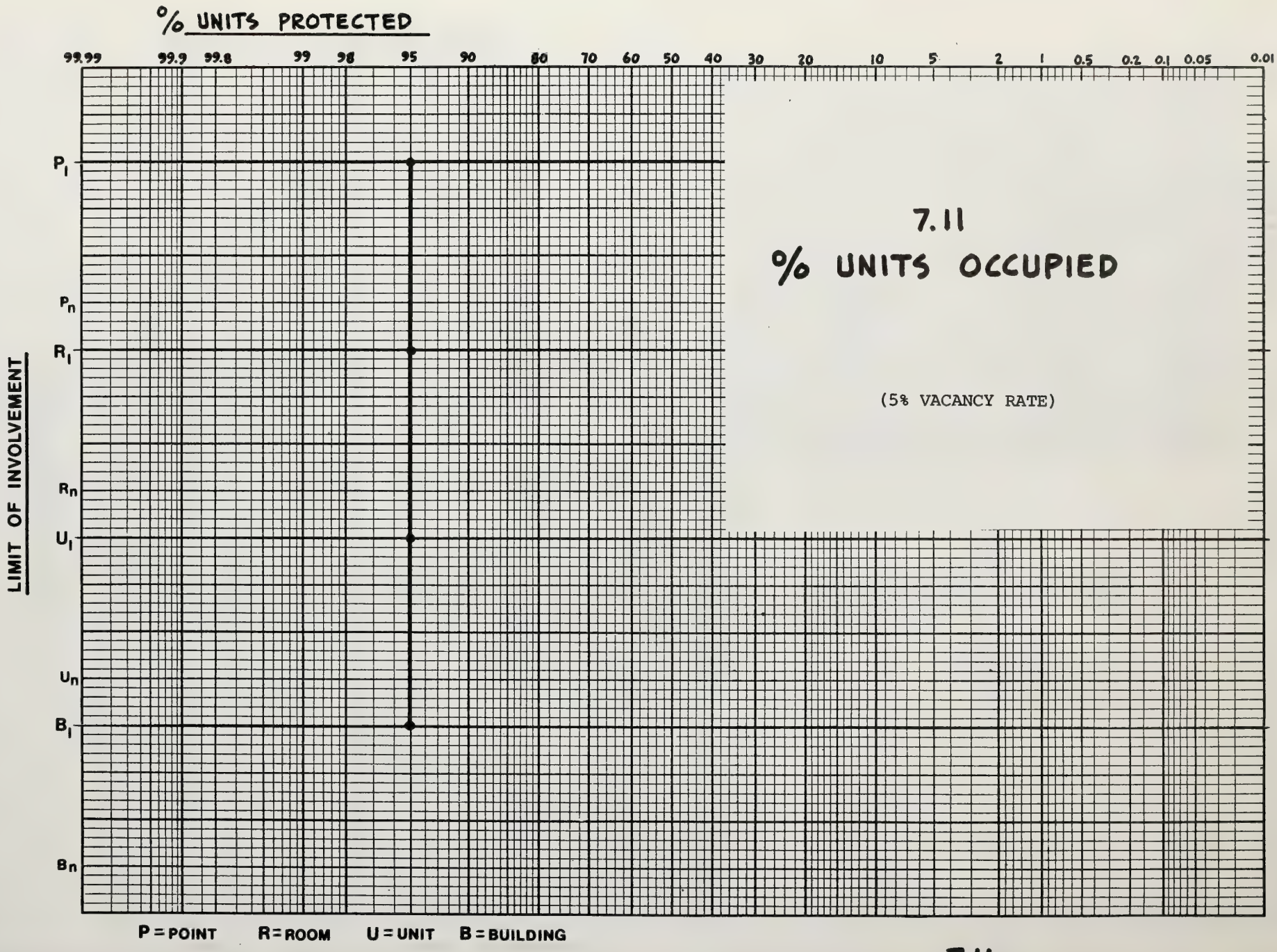
Chart 7.10 shows the ability of the occupant to limit total damage. The curve is the product of the fire fighting damage and the fire damage combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.8932
.0001
.9779
.9801
7.10
OCCUPANT ACTION
CONTRIBUTORY
CURVE REFERENCE
7.20
7.30
P = POINT
R = ROOM
U = UNIT
B = BUILDING

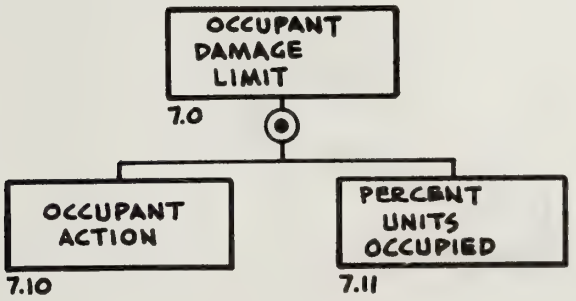
III-2.83 - Chart 7.11 - Percent Units Occupied

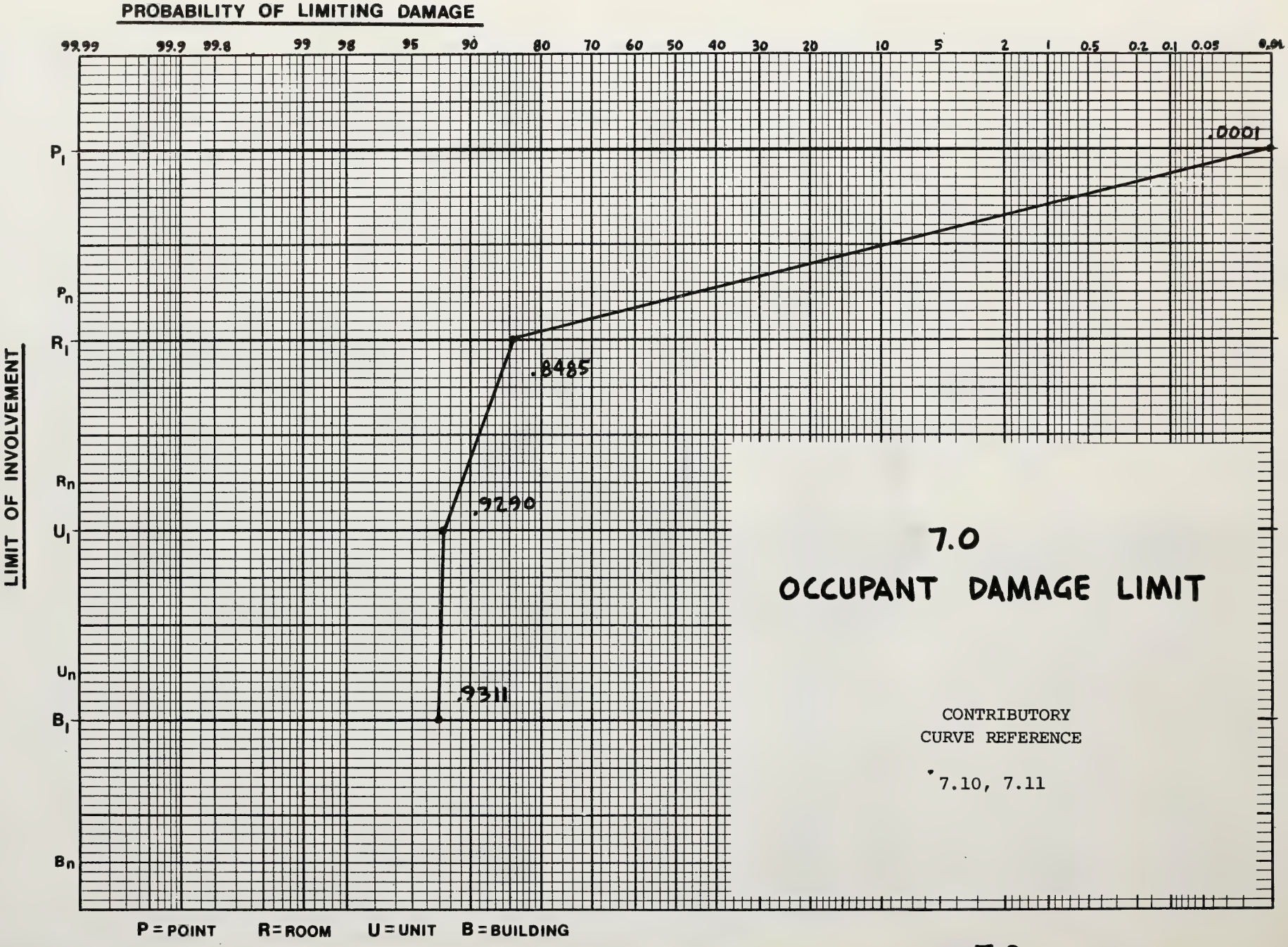
Chart 7.11 represents the percent of the residential units in the country which are occupied. The curve is based on estimates contained in the Statistical Abstract of the United States (115).


% UNITS PROTECTED
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
7.11
% UNITS OCCUPIED
(5% VACANCY RATE)
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.84 - Chart 7.0 - Occupant Damage Limit

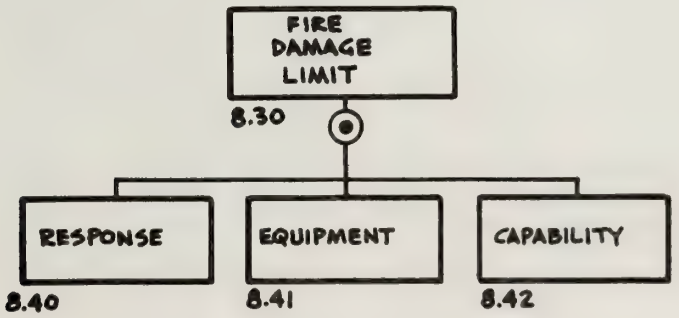
Chart 7.0 represents the ability of the occupant to limit total damage on a national basis. It is the product of the occupant action and the percent of the residential units occupied combined through an "AND" gate.

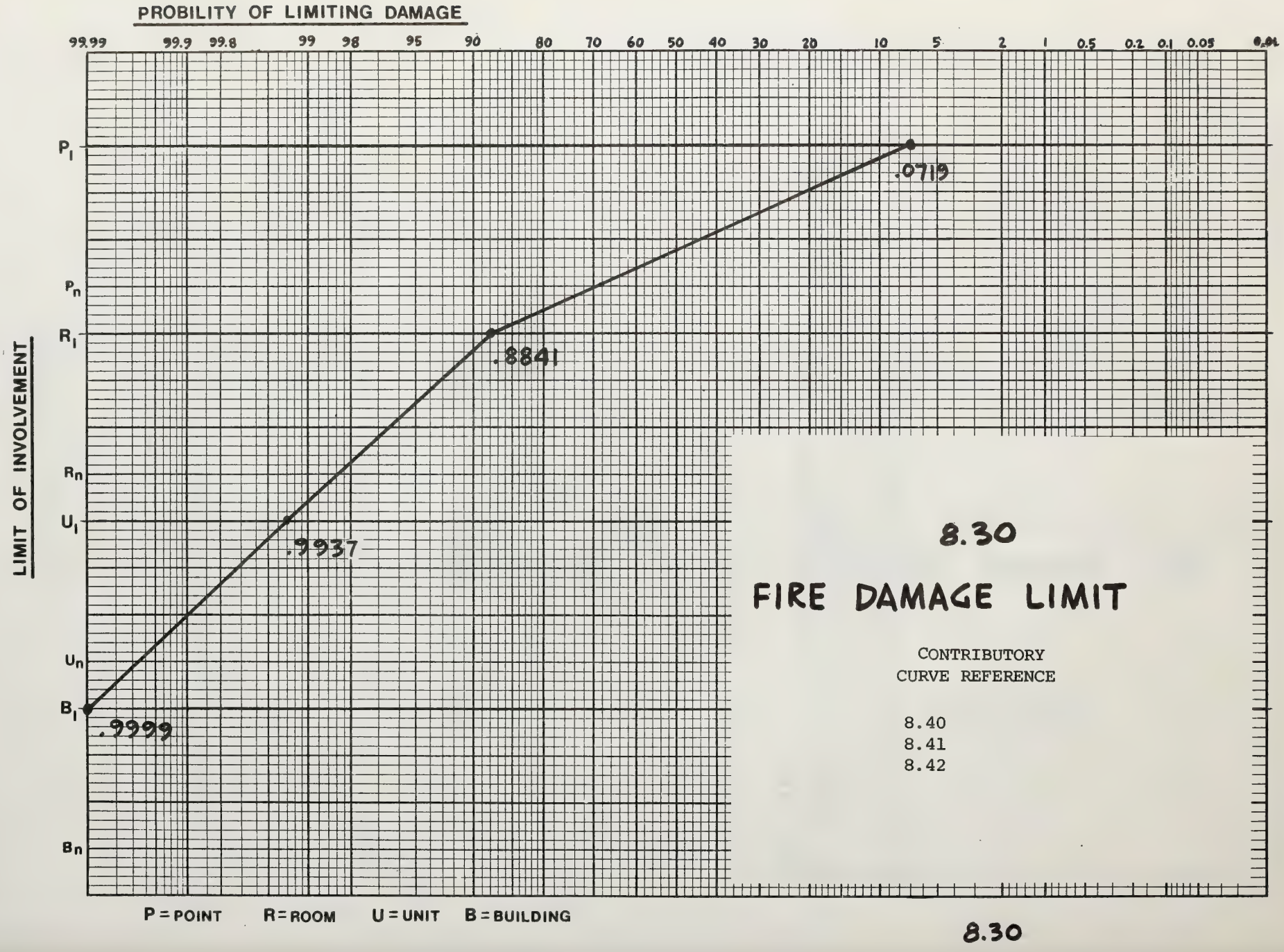



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0001
.8485
.9290
.9311
7.0
OCCUPANT DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
7.10, 7.11
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.85 - Chart 8.30 - Fire Damage Limit

Chart 8.30 shows the ability of the fire department to limit fire damage. It is the product of the response, equipment and capability of the fire department combined through an "AND" gate.

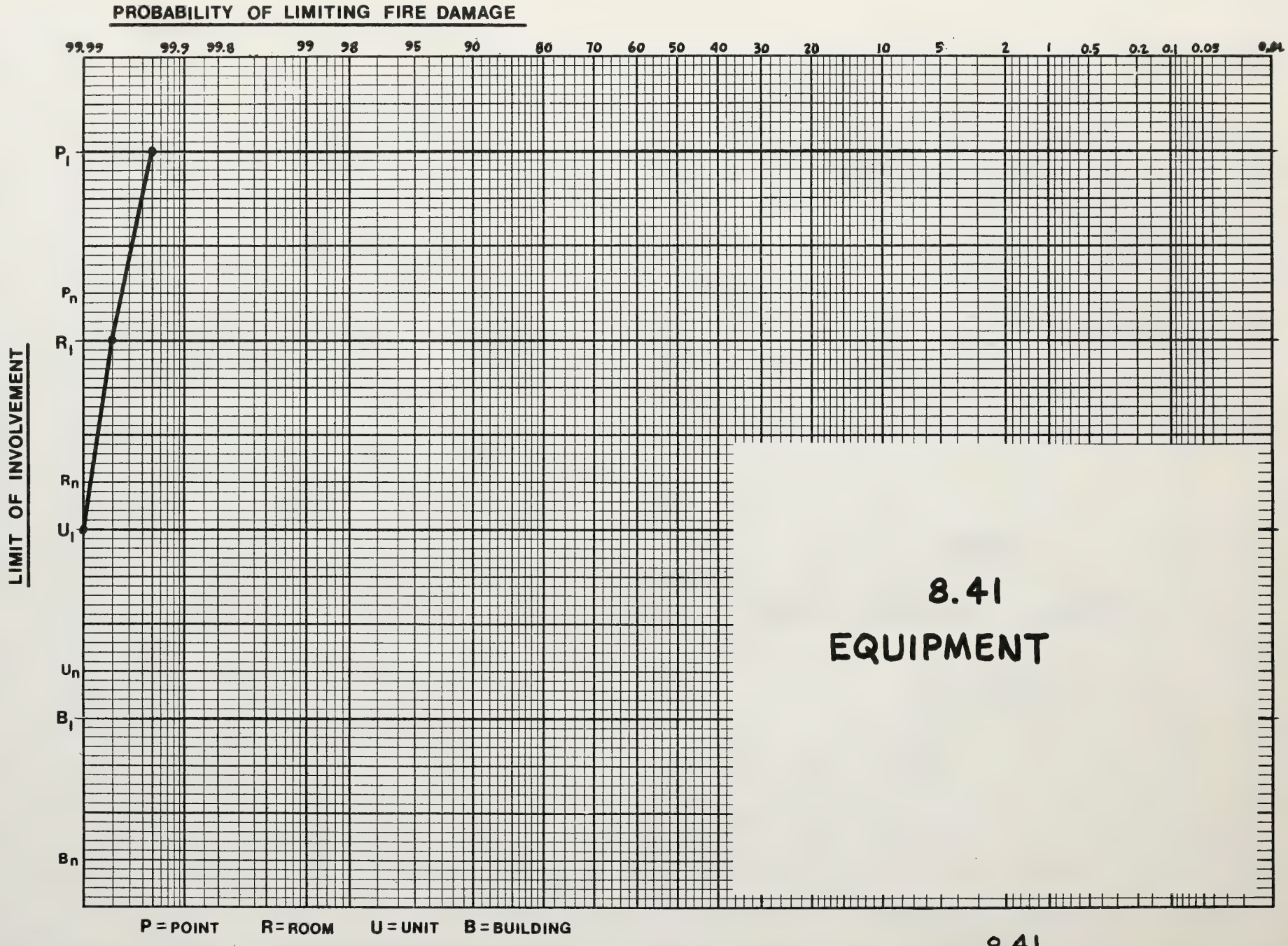



PROBILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.0719
.8841
.9937
.9999
8.30
FIRE DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
8.40
8.41
8.42
P = POINT
R = ROOM
U = UNIT
B = BUILDING

8.30

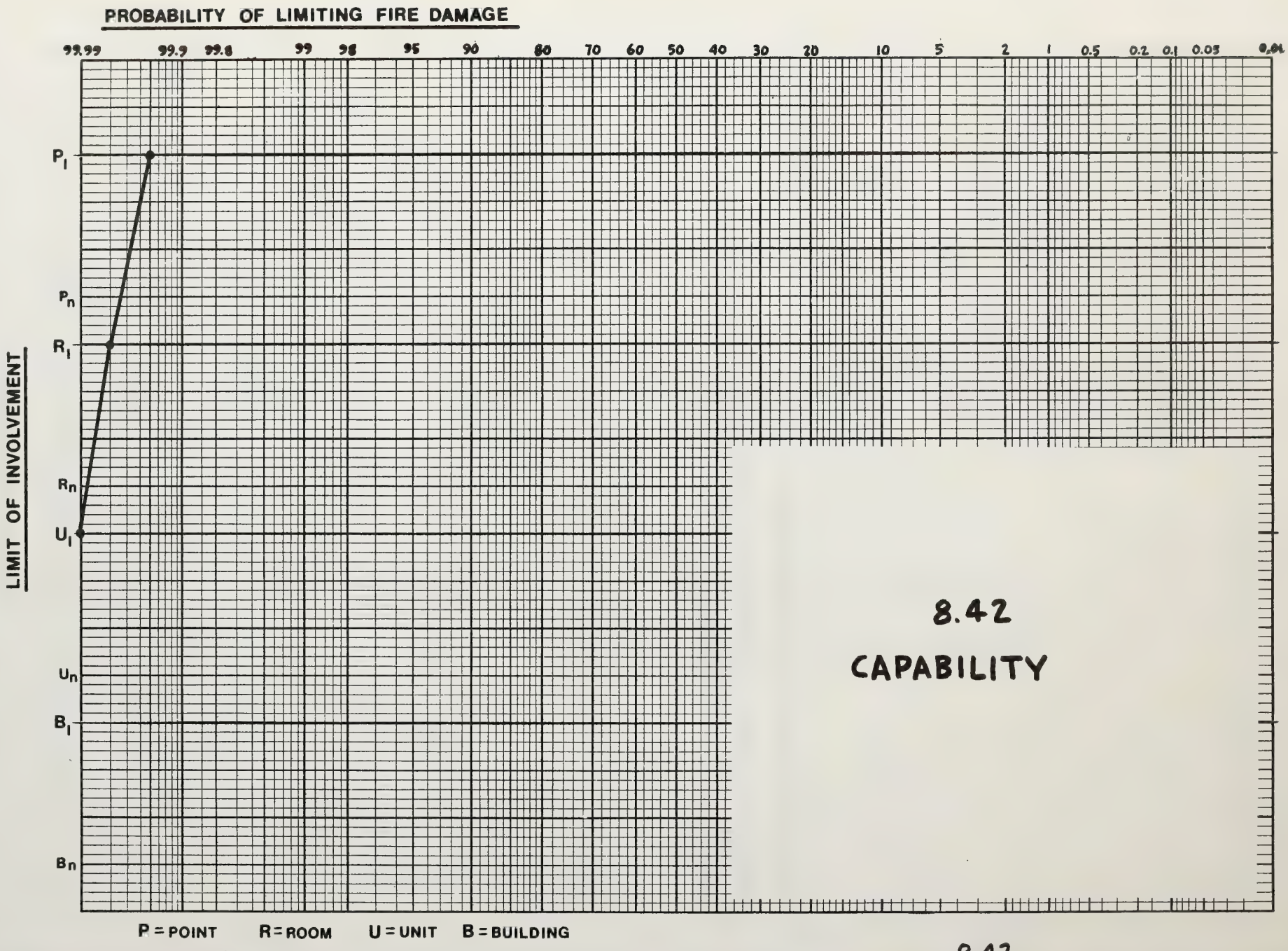
III-2.86 - Chart 8.41 - Equipment

Chart 8.41 shows the effect of fire fighting equipment on limiting fire damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_1
P_n
R_1
R_n
U_1
U_n
B_1
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.41
EQUIPMENT

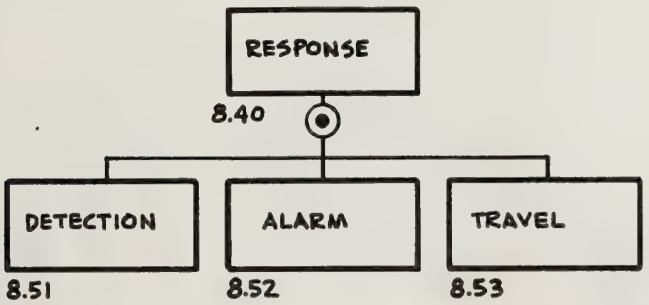
III-2.87 - Chart 8.42 - Capability

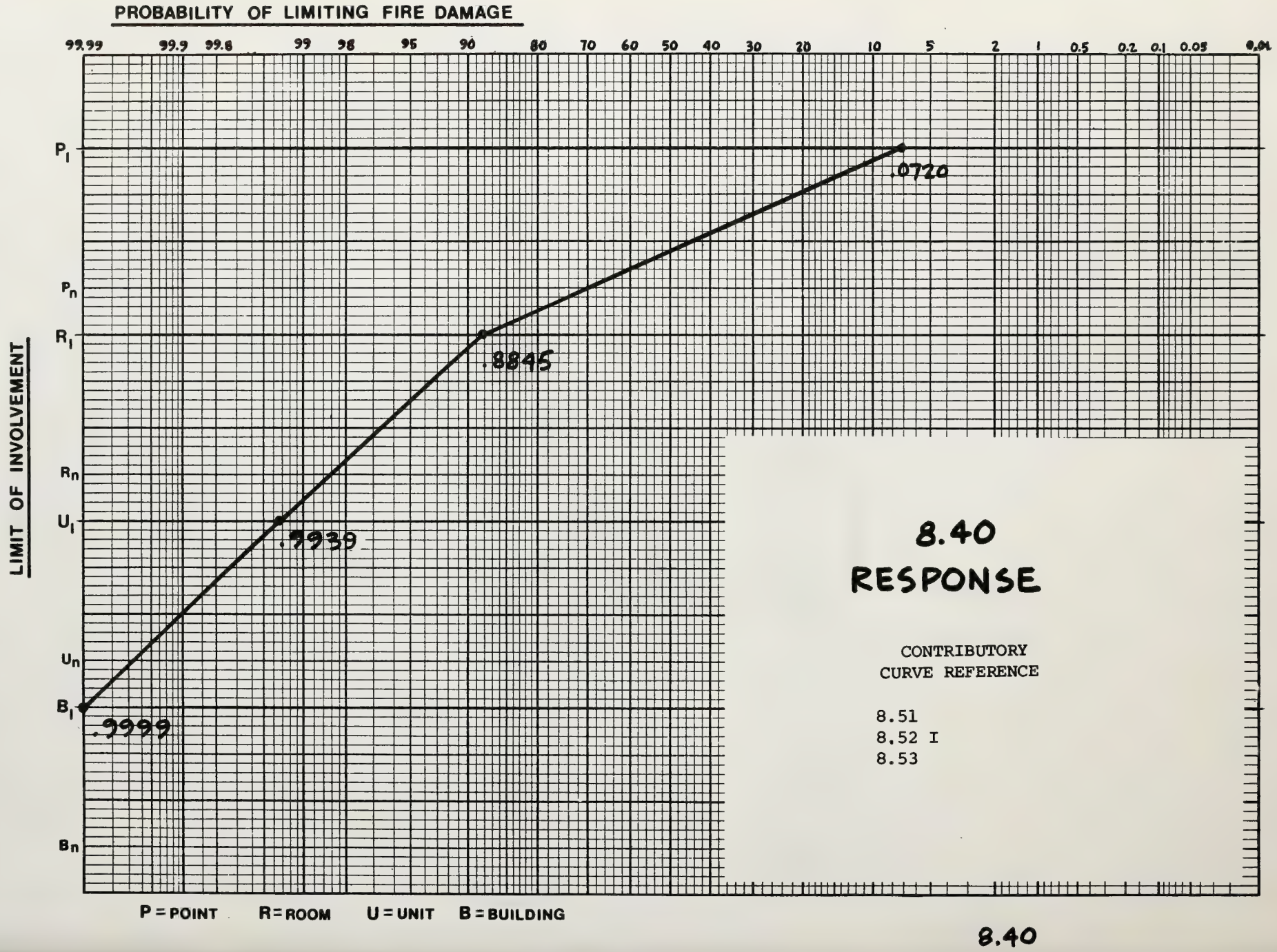
Chart 8.42 shows the ability of the responding firemen to limit fire damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.42
CAPABILITY

III-2.88 - Chart 8.40 - Response

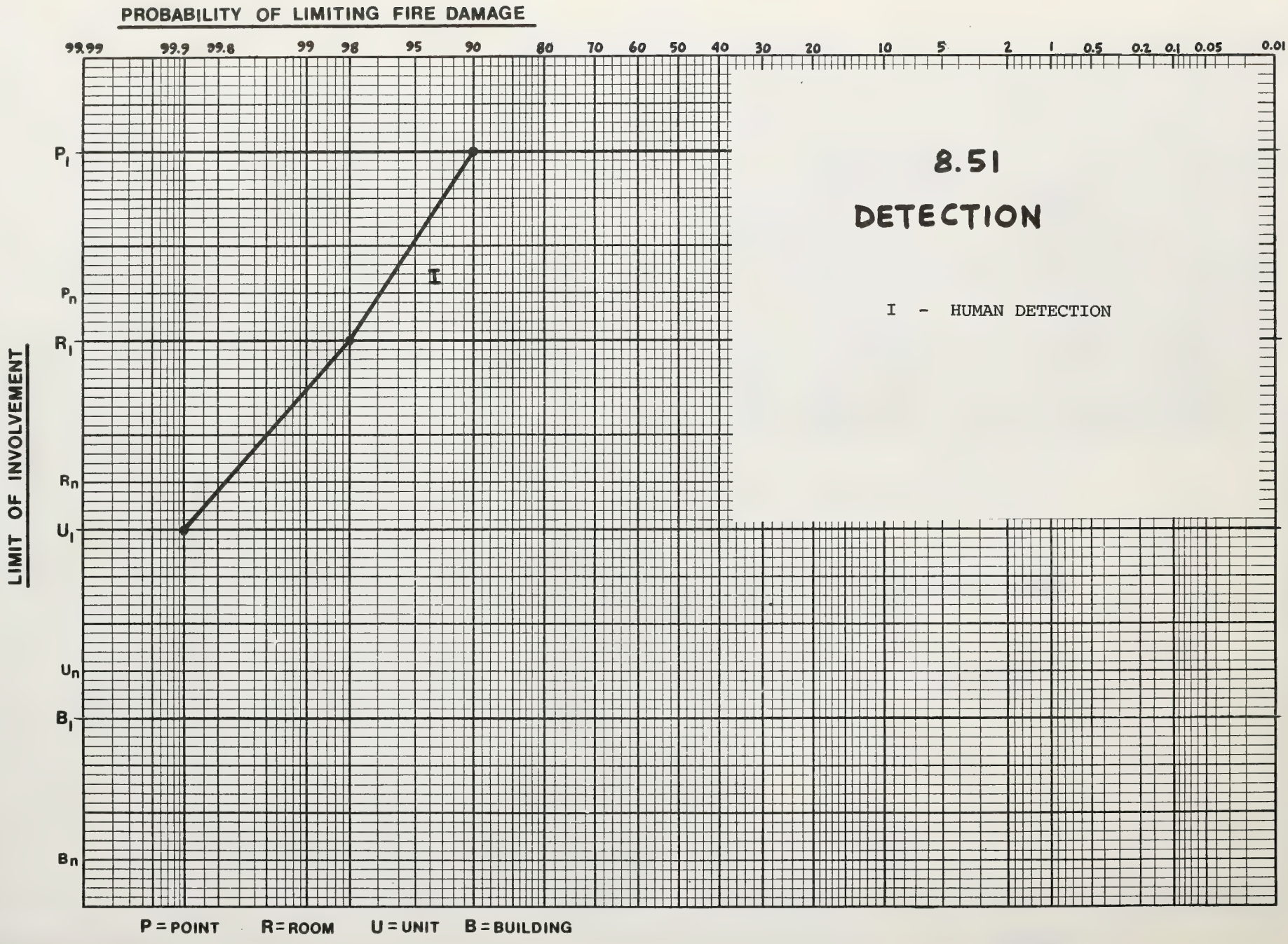
Chart 8.40 shows the effect of response in limiting fire damage. It is the product of fire detection, fire alarm and travel combined through an "AND" gate.




PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0720
.8845
.9939
.9999
8.40
RESPONSE
CONTRIBUTORY
CURVE REFERENCE
8.51
8.52 I
8.53
P = POINT
R = ROOM
U = UNIT
B = BUILDING

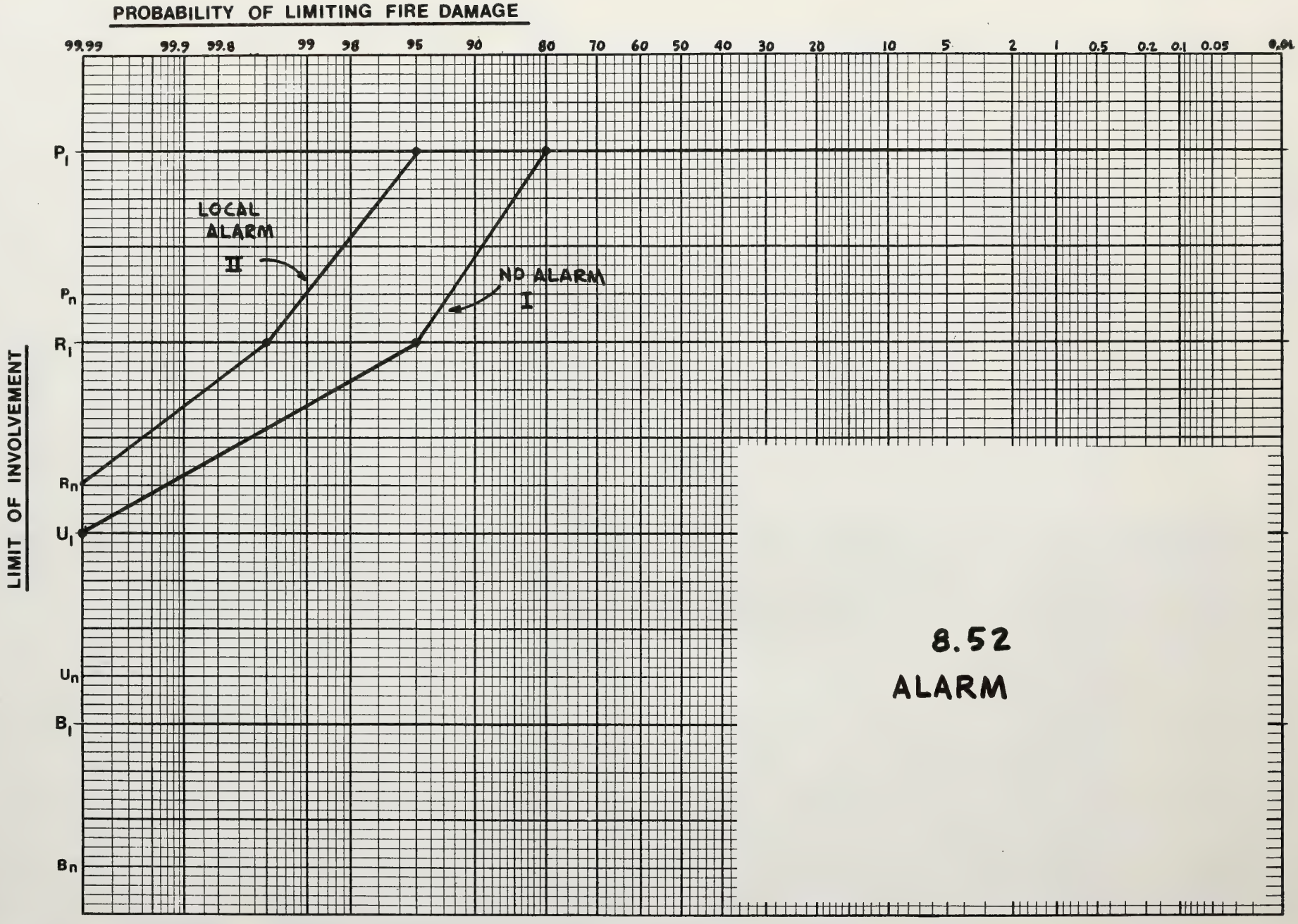
III-2.89 - Chart 8.51 - Detection

Chart 8.51 shows the effect of fire detection in limiting fire damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
8.51
DETECTION
I - HUMAN DETECTION
P = POINT
R = ROOM
U = UNIT
B = BUILDING

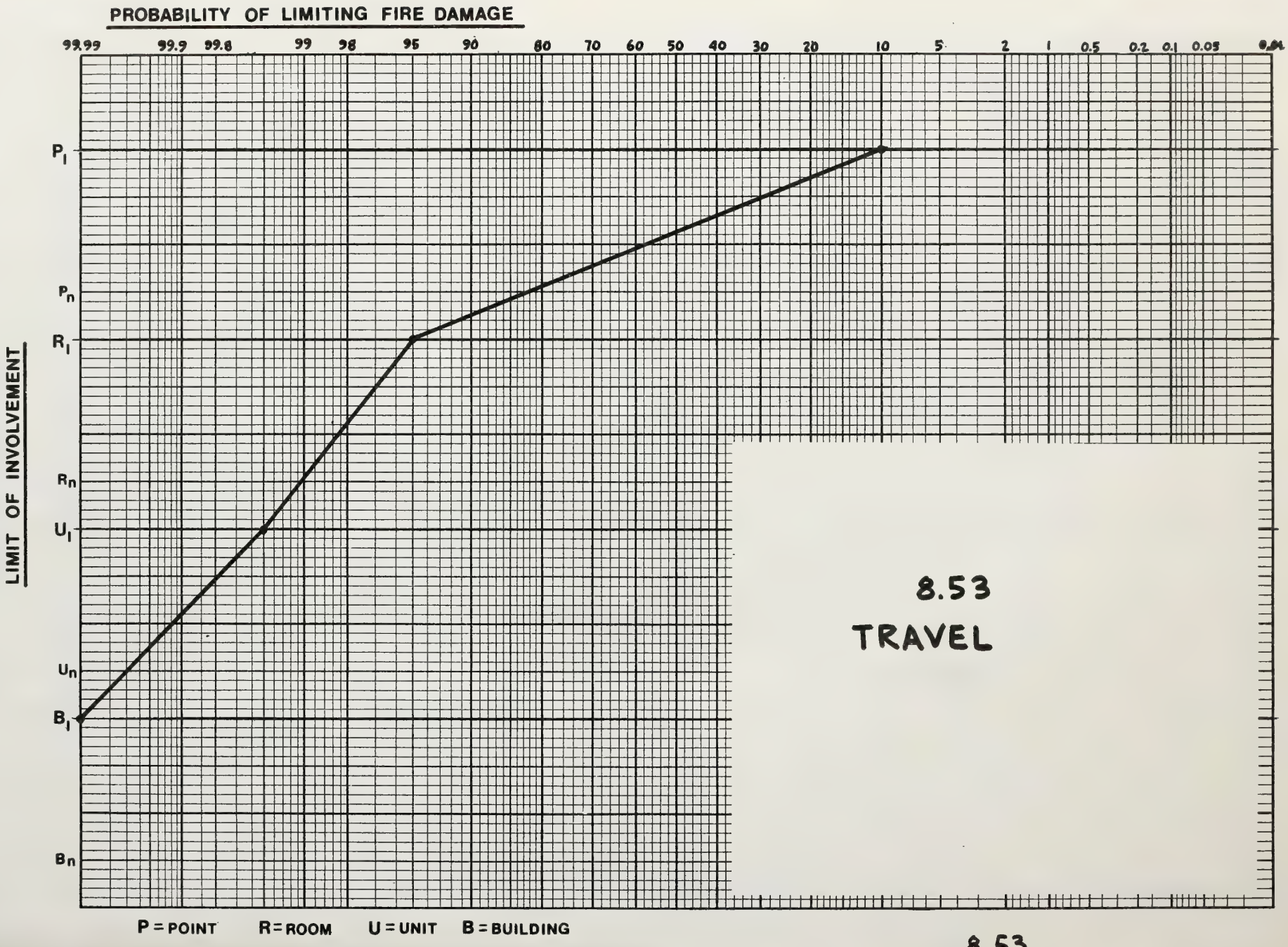
III-2.90 - Chart 8.52 - Alarm

Chart 8.52 shows the effect of alarm transmission after fire is detected. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
LOCAL ALARM
II
NO ALARM
I
8.52
ALARM
P = POINT
R = ROOM
U = UNIT
B = BUILDING

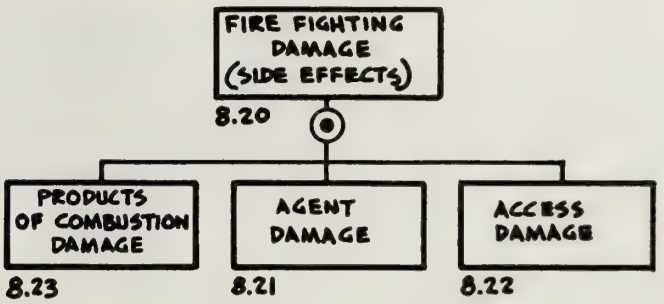
III-2.91 - Chart 8.53 - Travel

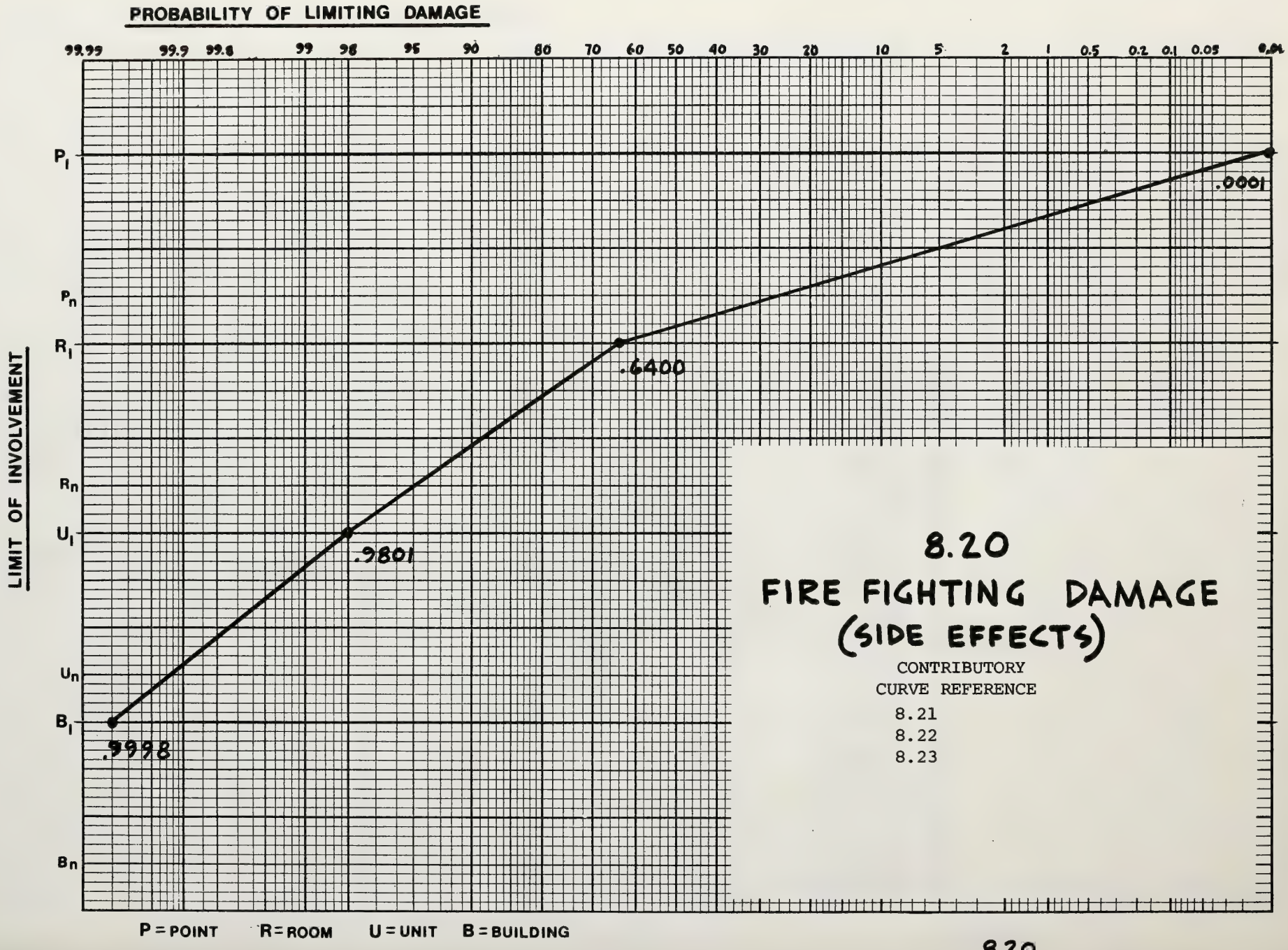
Chart 8.53 illustrates the effect of fire department travel distance on fire damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.53
TRAVEL

III-2.92 - Chart 8.20 Fire Fighting Damage

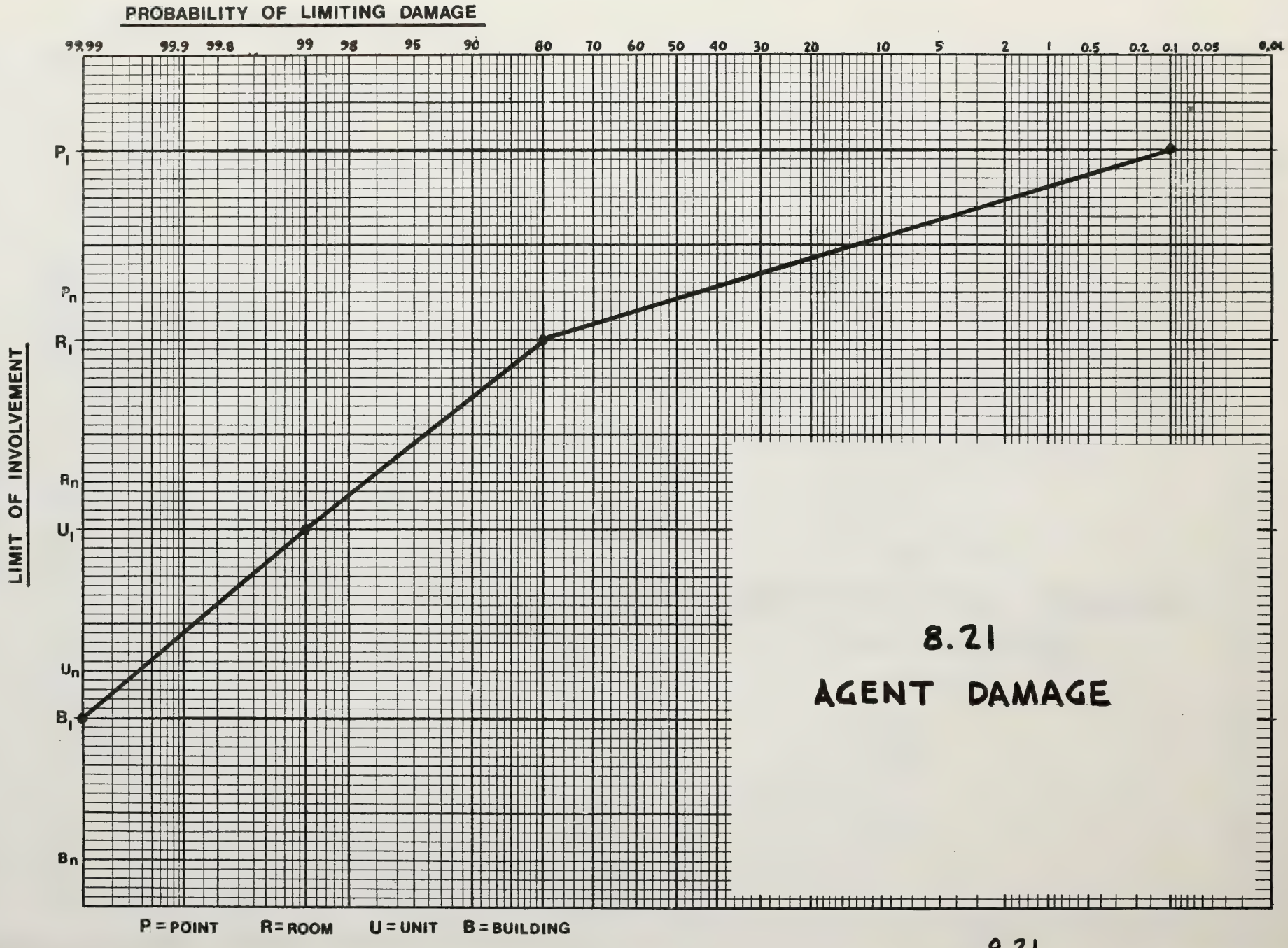
Chart 8.20 shows the damage caused by manual fire fighting. The curve was developed using the product of agent damage, access damage and products of combustion damage combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.9998
.9801
.6400
.0001
8.20
FIRE FIGHTING DAMAGE
(SIDE EFFECTS)
CONTRIBUTORY
CURVE REFERENCE
8.21
8.22
8.23
P = POINT
R = ROOM
U = UNIT
B = BUILDING

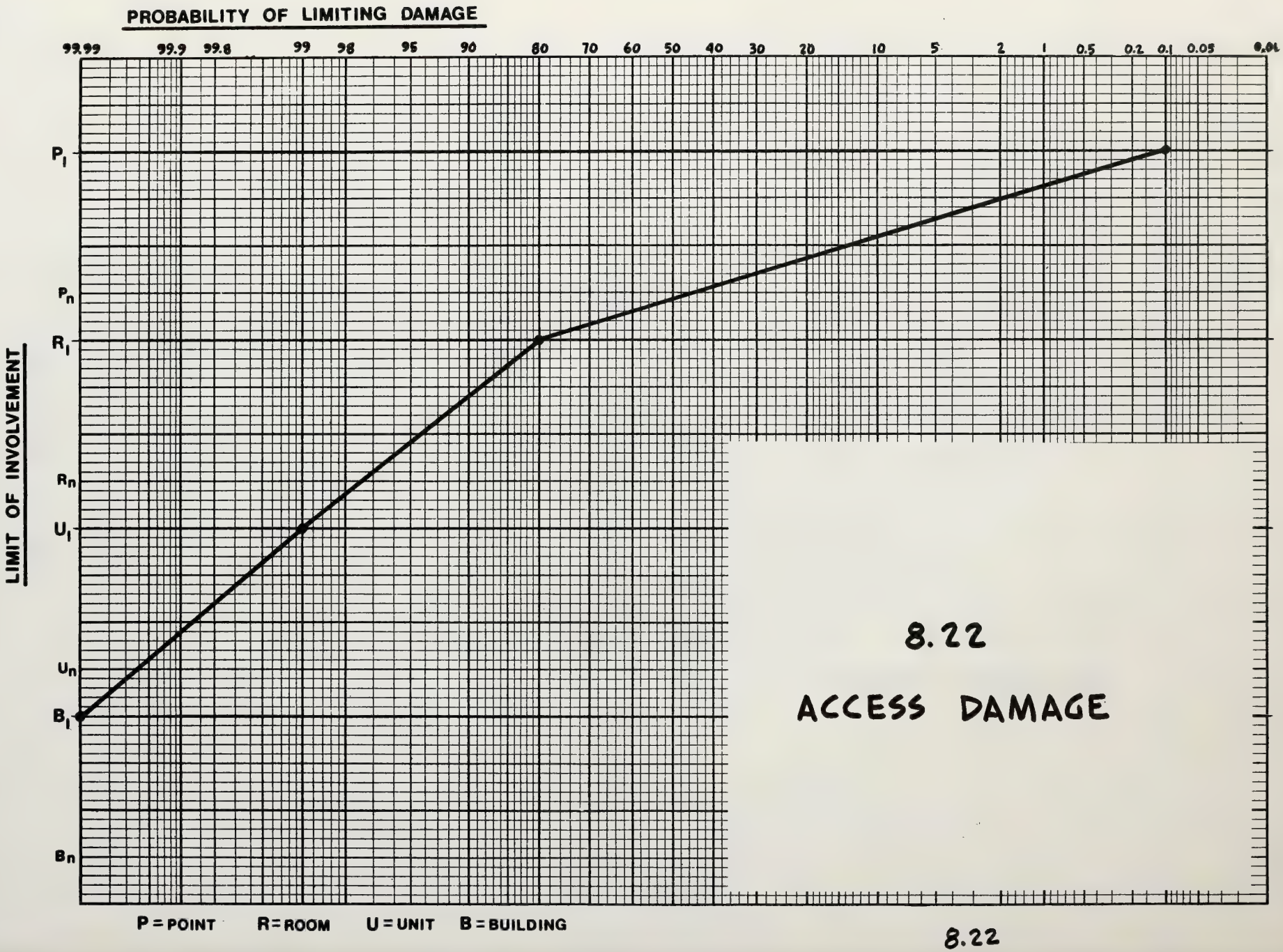
III-2.93 - Chart 8.21 - Agent Damage

Chart 8.21 shows the ability of manual fire fighting to limit agent damage. The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.21
AGENT DAMAGE

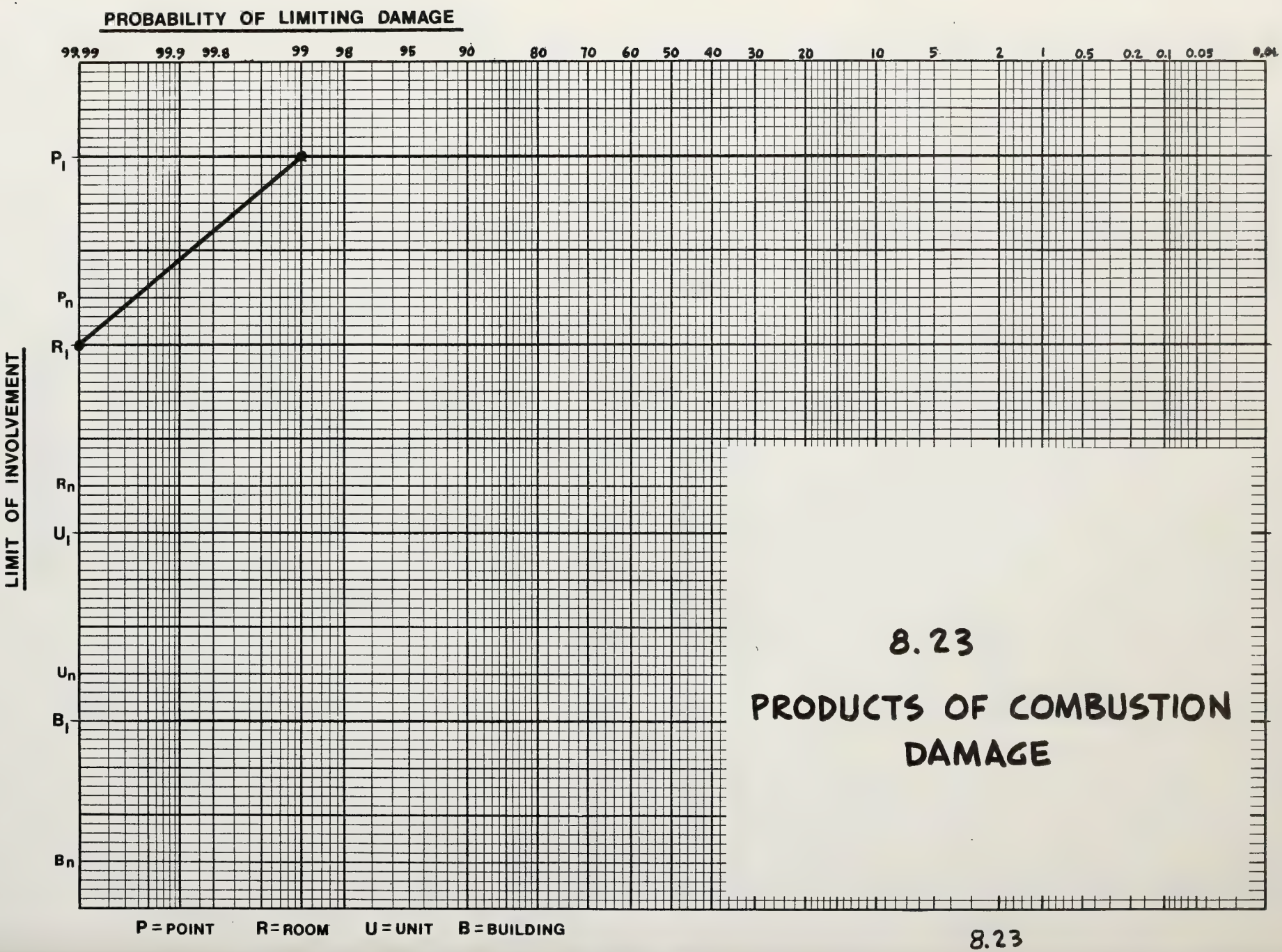
III-2.94 - Chart 8.22 - Access Damage

Chart 8.22 shows the ability of manual fire fighting to limit access damage (i.e. damage caused by forceful entry, by opening concealed spaces in walls, by ventilation through walls, windows or roofs etc.) The curve is based on judgment, considering fire records.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.22
ACCESS DAMAGE

III-2.95 - Chart 8.23 - Products of Combustion Damage

Chart 8.23 shows the ability of fire fighters to limit the increased products of combustion damage caused during the control/extinguishing process. The curve is based on judgment, considering fire records and research data.

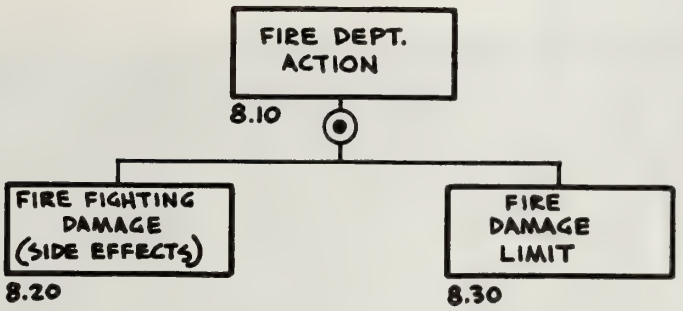


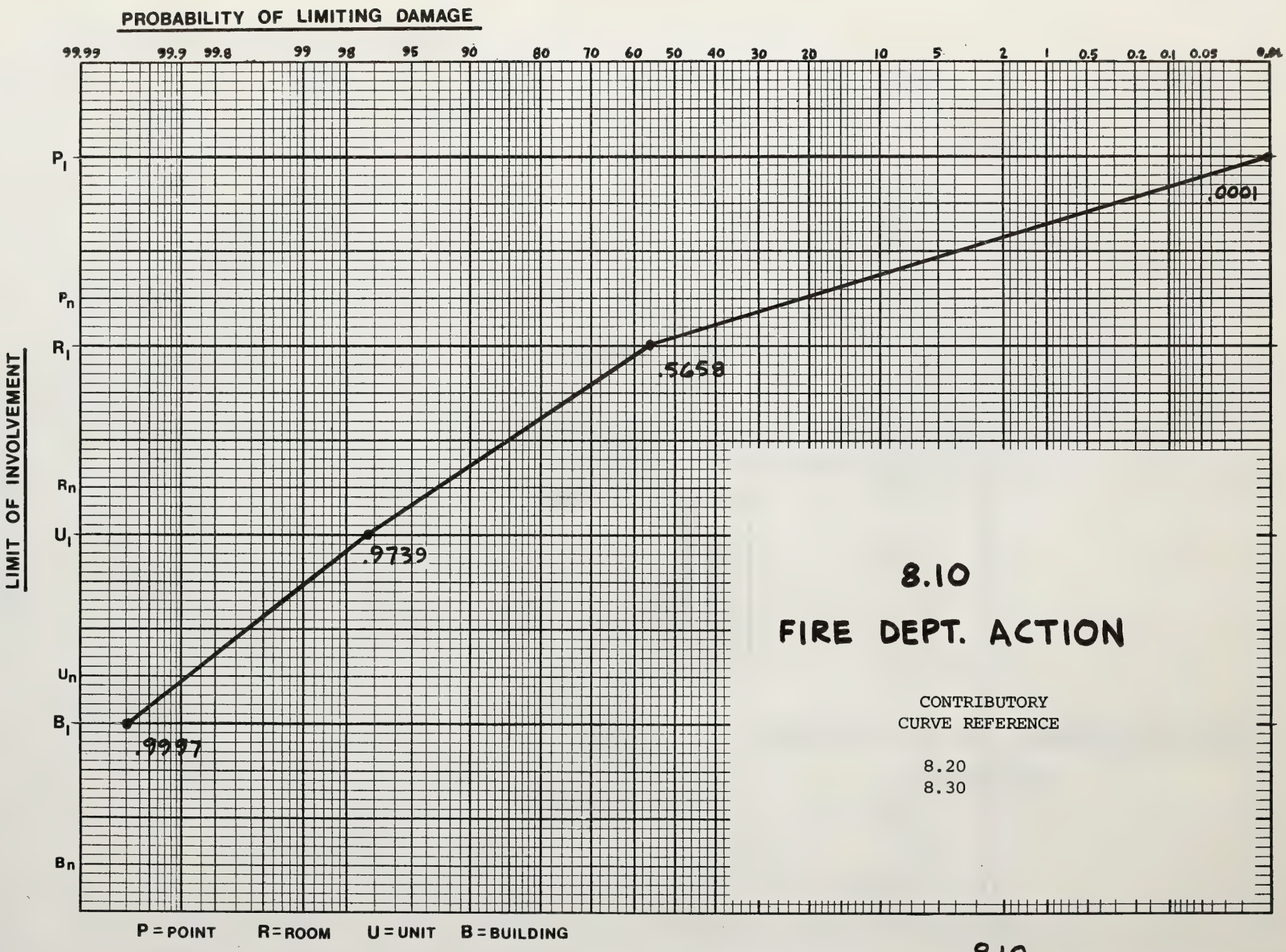
8.23

PRODUCTS OF COMBUSTION DAMAGE

III-2.96 - Chart 8.10 Fire Department Action

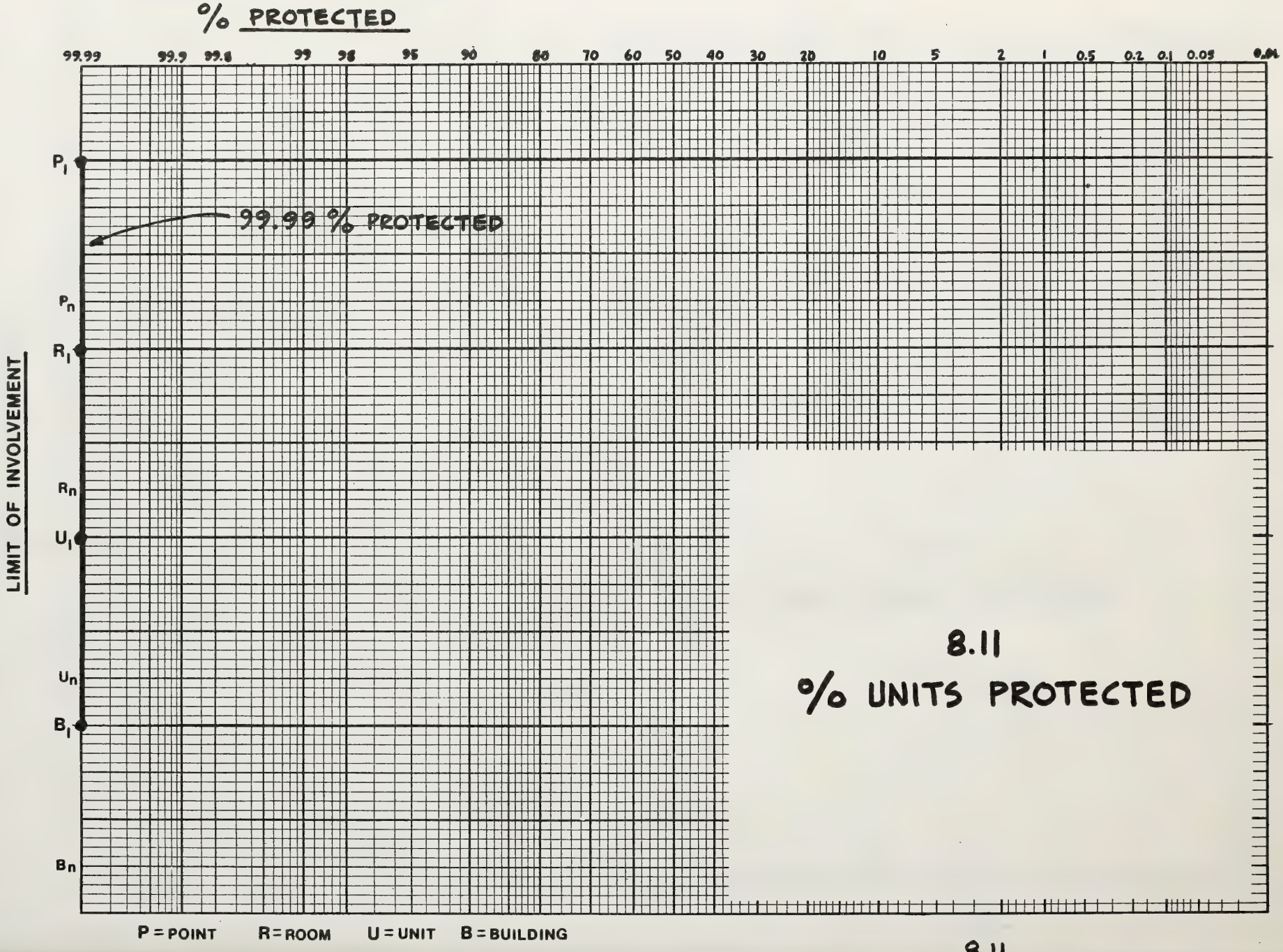
Chart 8.10 shows the ability of the fire department to limit total damage. The curve is the product of the fire fighting damage and the fire damage limit combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0001
.5658
.9739
.9997
8.10
FIRE DEPT. ACTION
CONTRIBUTORY
CURVE REFERENCE
8.20
8.30
P = POINT
R = ROOM
U = UNIT
B = BUILDING

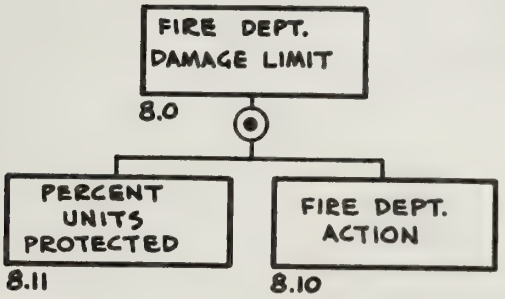
III-2.97 - Chart 8.11 - Percent Units Protected

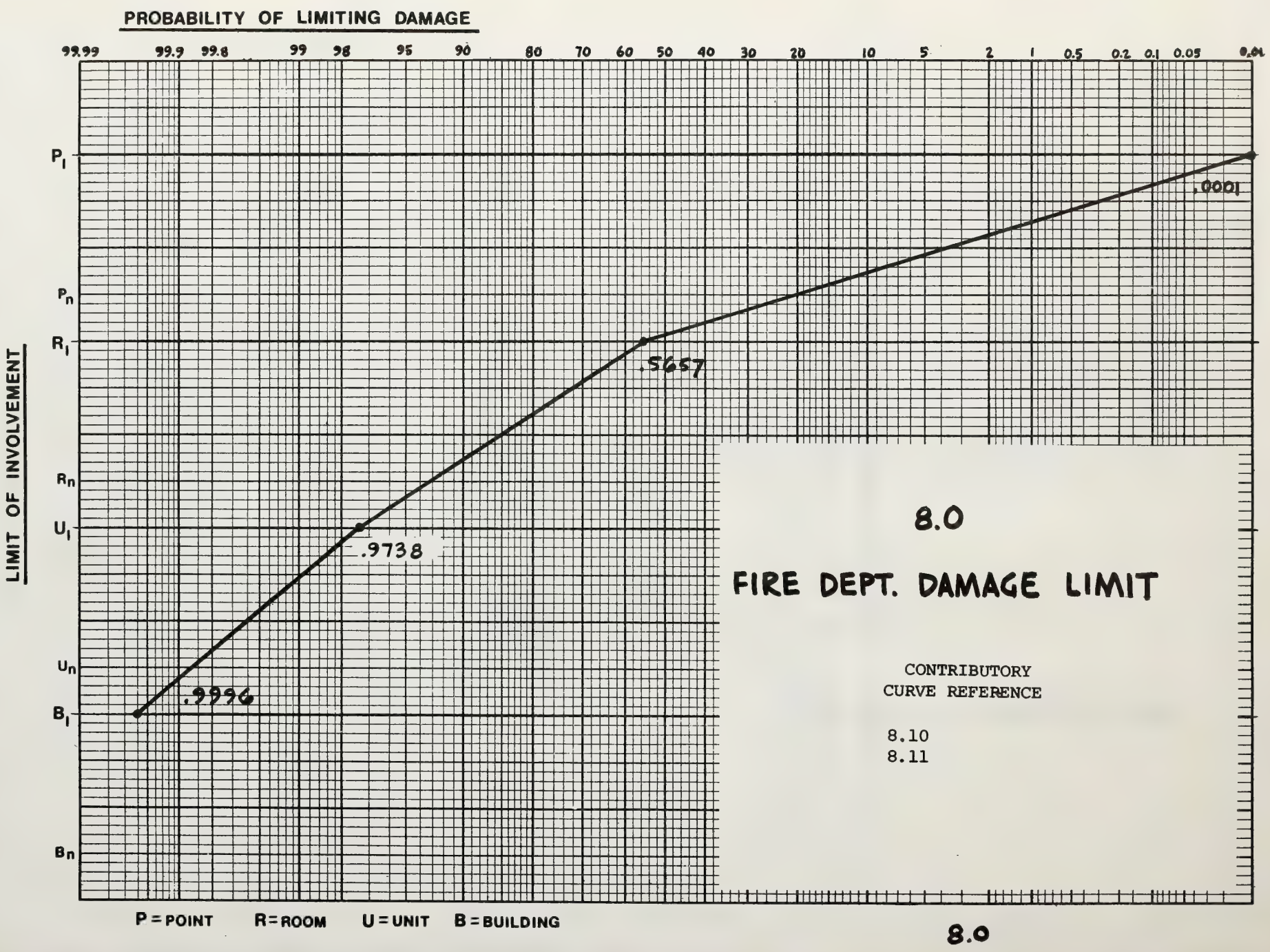
Chart 8.11 represents the percent of residential units in the country which are protected by fire department response. The curve is based on estimated number of protected residences.


% PROTECTED
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
99.99 % PROTECTED
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.11
% UNITS PROTECTED

III-2.98 - Chart 8.0 - Fire Department Damage Limit

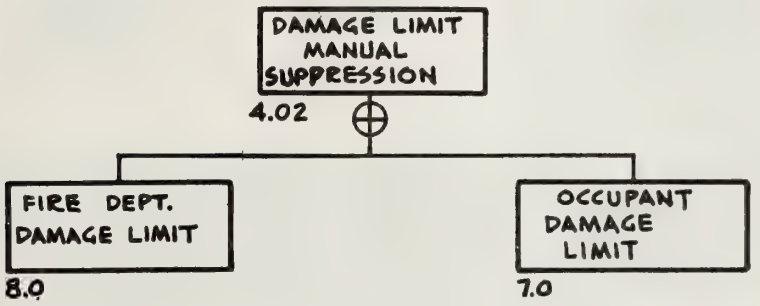
Chart 8.0 represents the ability of the fire department to limit total damage on a national basis. It is the product of the fire department action and the percent of residential units protected combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0001
.5657
.9738
.9996
8.0
FIRE DEPT. DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
8.10
8.11
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.0

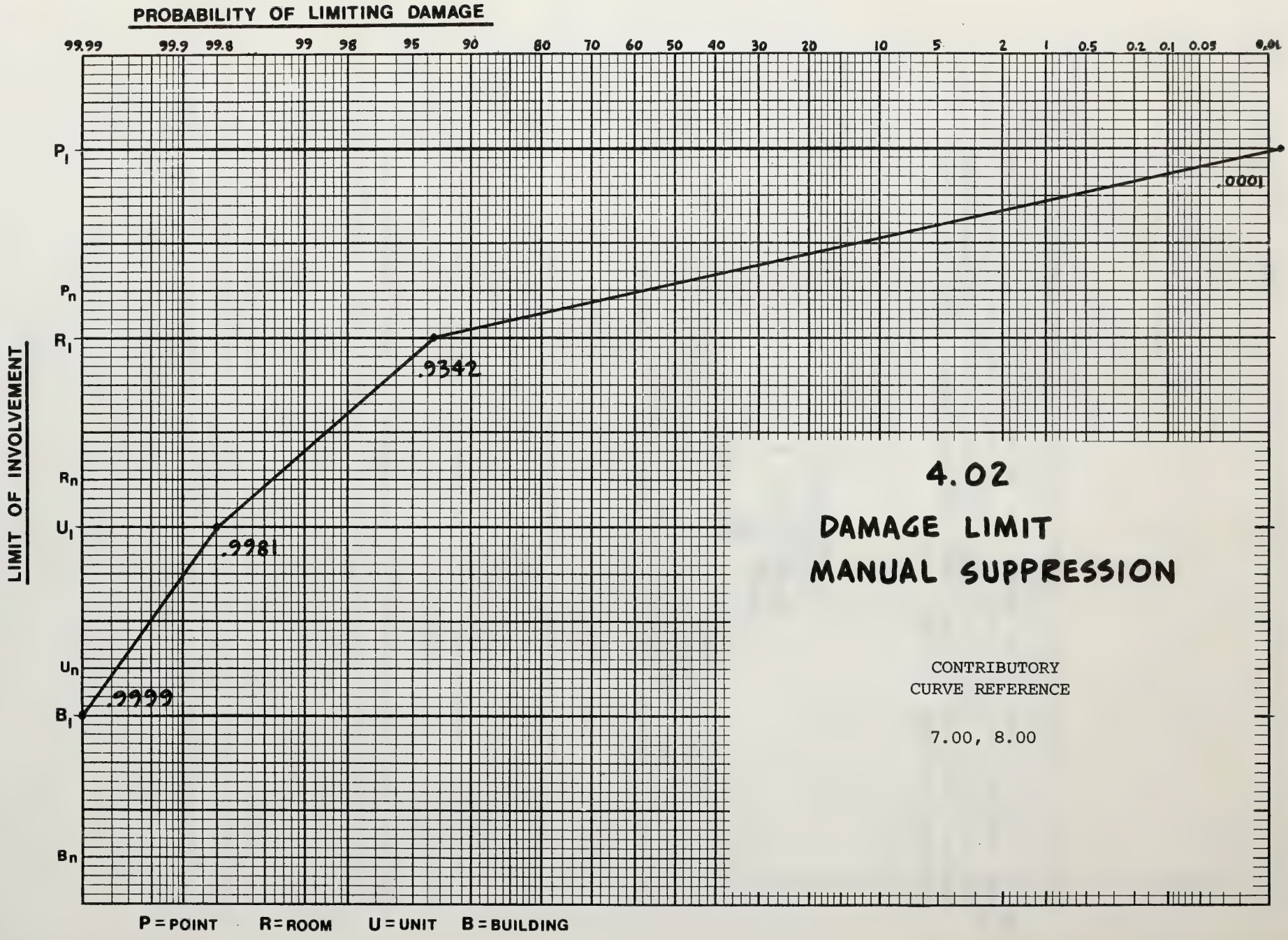
III-2.99 - Chart 4.02 - Damage Limit Manual Suppression

III-2.99.1 Chart 4.02 shows the effect of the fire department and the occupant in limiting damage on a national basis. The curve was developed using the sum of the fire department damage limit ability and the occupant damage limit ability combined through an "OR" gate.



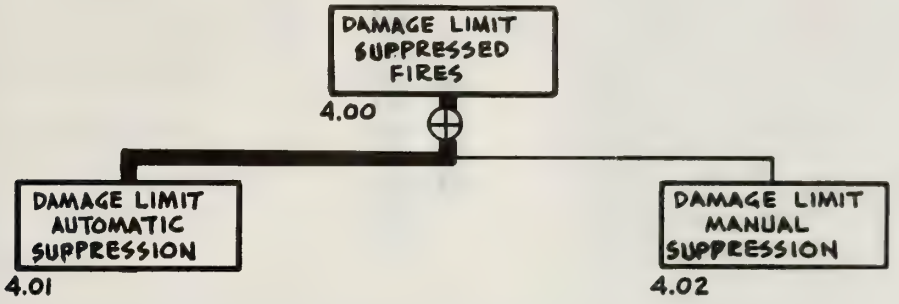
III-2.99.2 The curve represents current manual fire fighting conditions in this country.

III-2.99.3 While investigation of manual suppression is beyond the scope of this project, this analysis is needed to evaluate the impact of automatic suppression systems on the National Residential Fire Loss.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.0001
.9342
.9981
.9999
4.02
DAMAGE LIMIT
MANUAL SUPPRESSION
CONTRIBUTORY
CURVE REFERENCE
7.00, 8.00
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.100 - Chart 4.0 - Damage Limit Suppressed Fires

III-2.100.1 Chart 4.0 represents the ability of an automatic suppression system to limit damage when used in conjunction with the existing manual suppression capability of the occupants and fire department. The curves were developed by combining the ability of the automatic suppression systems with the ability of the manual suppression forces through an "OR" gate.

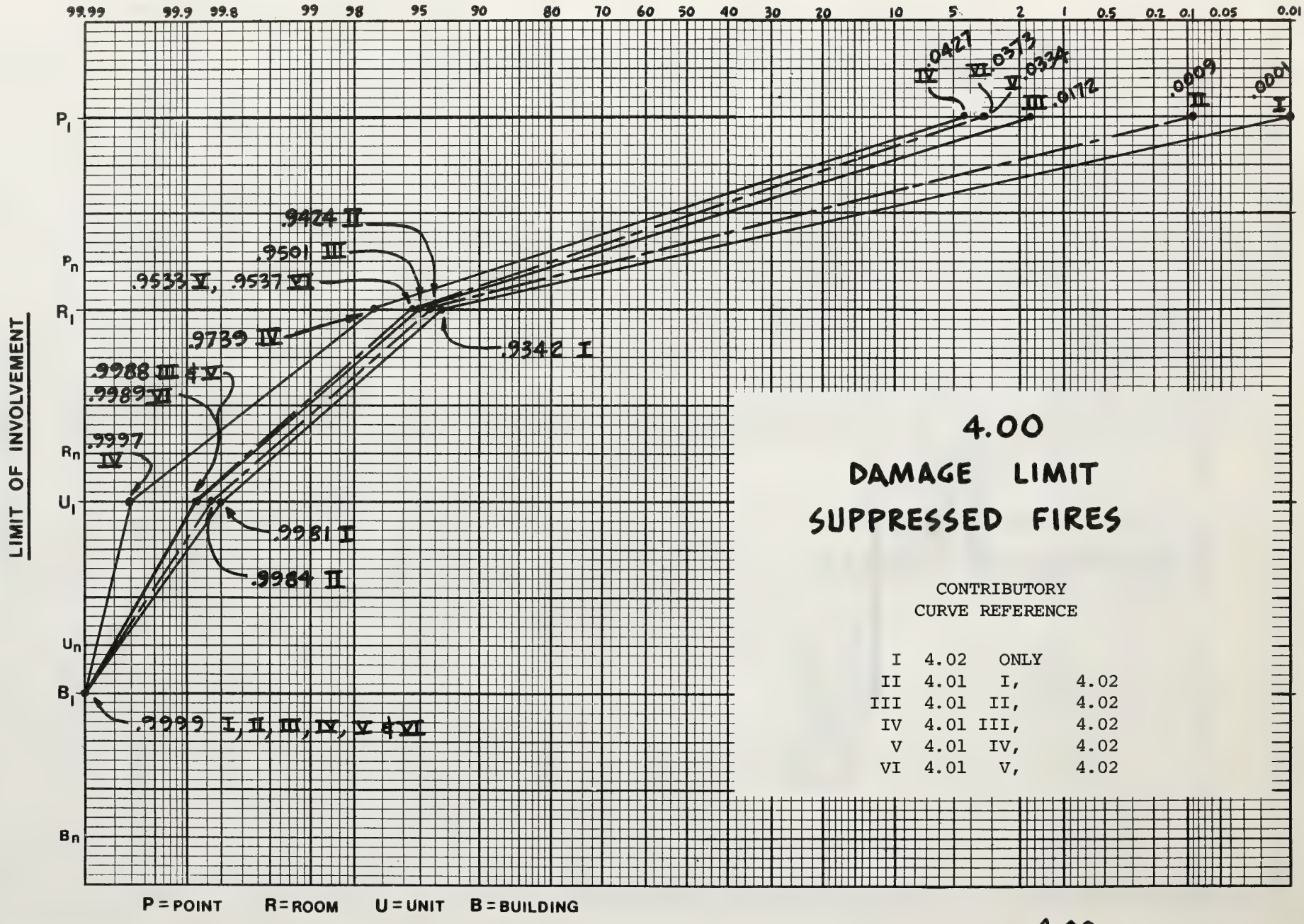


III-2.100.2 The differential between Curve I (no suppression systems) and the other curves, shows the ability of an automatic sprinkler system (as defined) to reduce damage nationally.

III-2.100.3 The curves shown on the chart represent:

- Curve I - No system.
- Curve II - Level I system installed on a voluntary basis (1990).
- Curve III - Level I system required in all new residential units (1990).
- Curve IV - Level I system installed in all residential units (1990).
- Curve V - Level II system required in all new residential units (1990).
- Curve VI - Level III system required in all new residential units (1990).

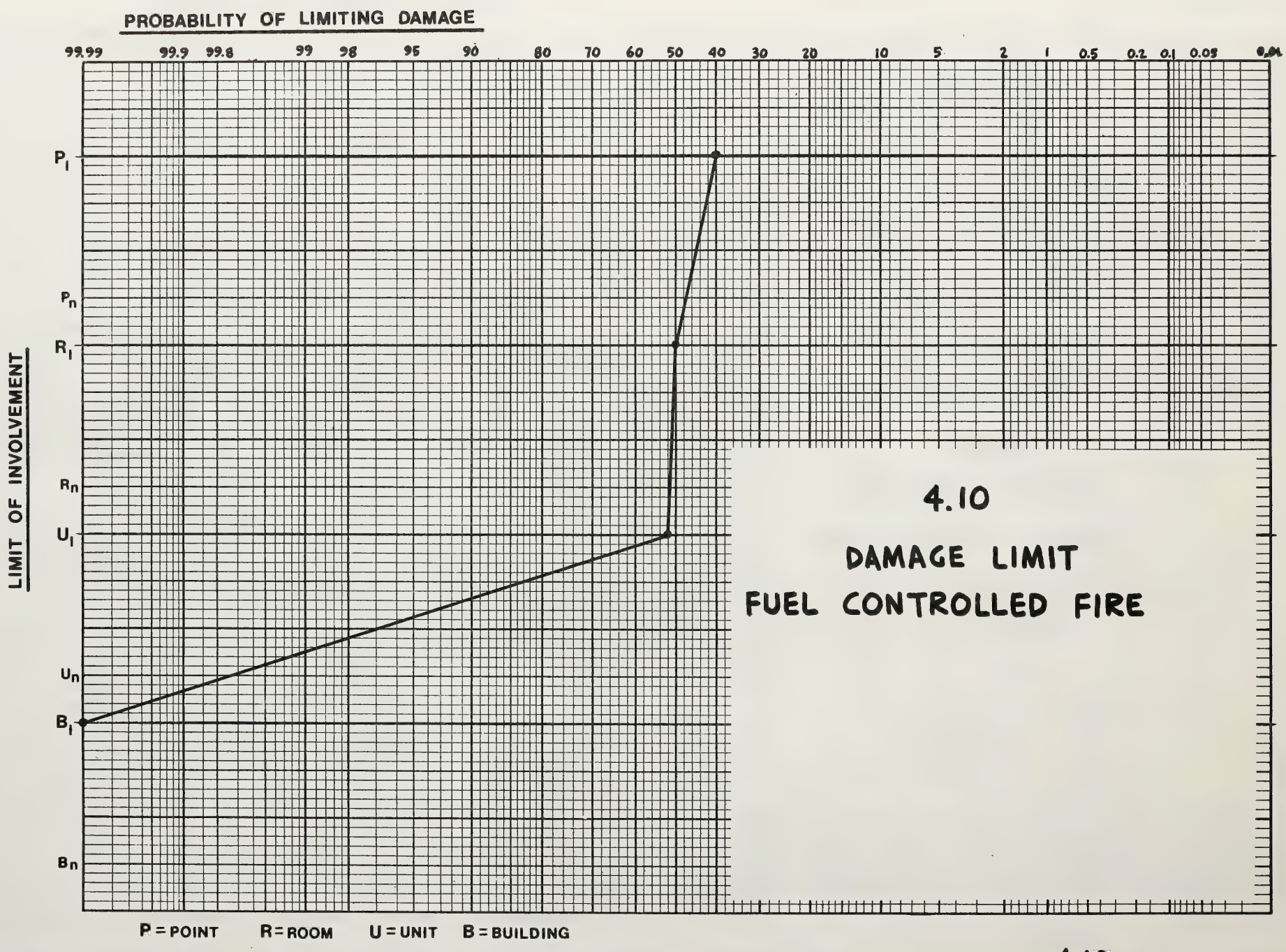
As shown on Chart 4.01-AS, the installed cost of these systems is considered to be the target cost of $0.20/sq. ft.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0427 IV
.0373 VI
.0334 V
.0172 III
.0009 II
.0001 I
.9424 II
.9501 III
.9533 V, .9537 VI
.9739 IV
.9342 I
.9988 III & V
.9989 VI
.9997 IV
.9981 I
.9984 II
.9999 I, II, III, IV, V & VI
4.00
DAMAGE LIMIT
SUPPRESSED FIRES
CONTRIBUTORY
CURVE REFERENCE
I 4.02 ONLY
II 4.01 I, 4.02
III 4.01 II, 4.02
IV 4.01 III, 4.02
V 4.01 IV, 4.02
VI 4.01 V, 4.02
P = POINT R = ROOM U = UNIT B = BUILDING

III-2.101 - Chart 4.10 - Damage Limit Fuel Controlled Fire

III-2.101.1 Chart 4.10 illustrates the effect of available fuel on fire damage. The curve is based on judgment, considering fire records and research data.

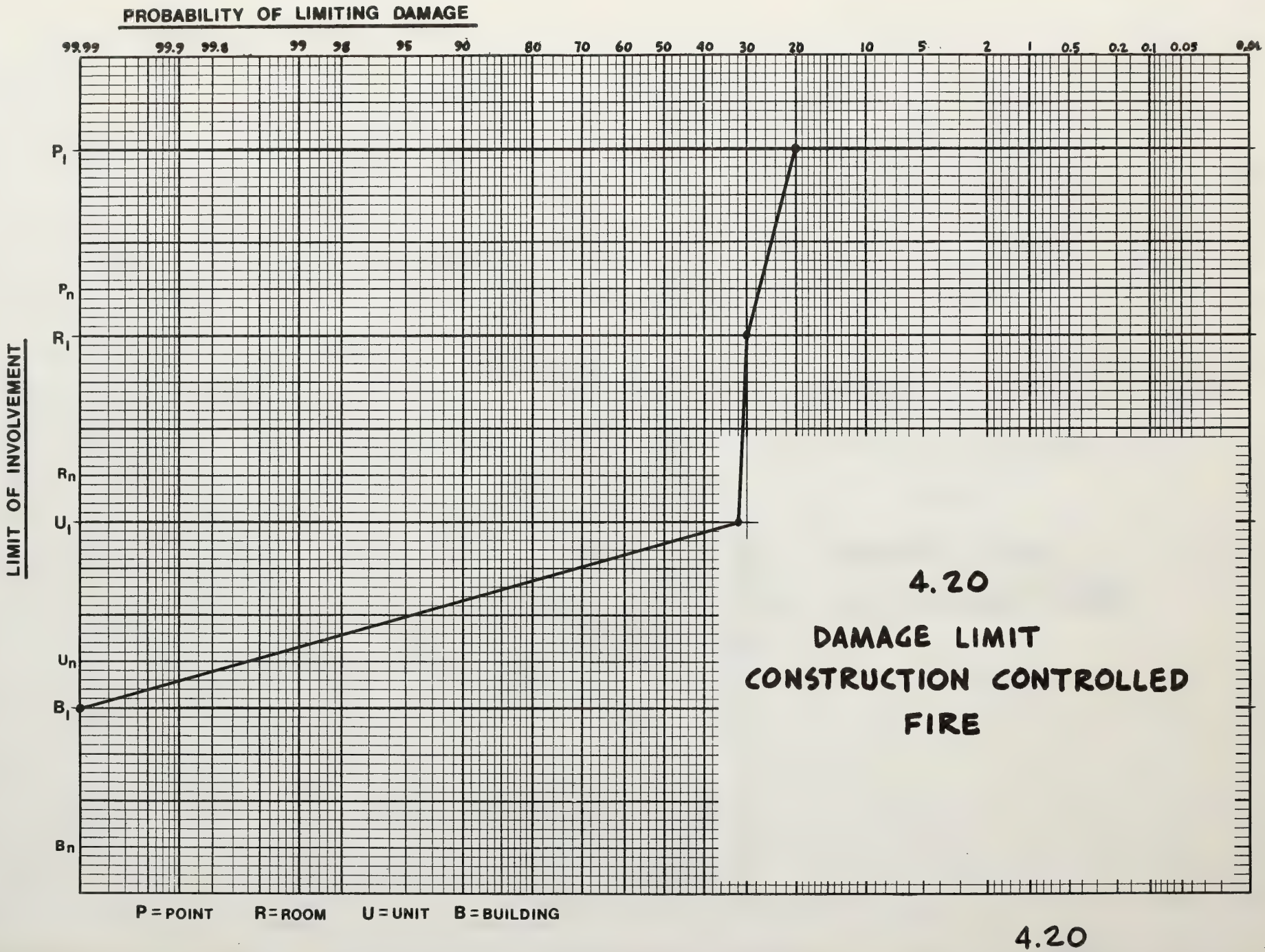
III-2.101.2 The curve considers furnishings which are currently in use. By increasing or decreasing the combustibility of furnishings, the National Residential Fire Loss may change. Investigation of this item is beyond the scope of this project.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
4.10
DAMAGE LIMIT
FUEL CONTROLLED FIRE
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-2.102 - Chart 4.20 - Damage Limit Construction Controlled Fire

III-2.102.1 Chart 4.20 illustrates the effect of building construction on fire damage. The curve was developed considering compliance with existing building codes. The curve is based on judgment, considering fire records and research data.

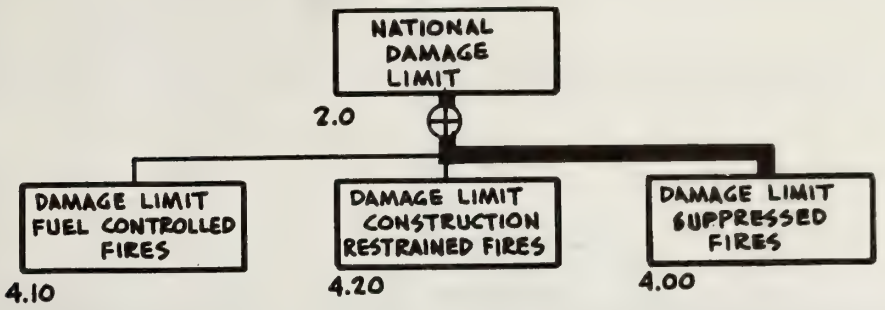
III-2.102.2 As building codes change to permit or restrict construction methods and materials, the National Residential Fire Loss may change. Investigation of this item is beyond the scope of this project.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
4.20
DAMAGE LIMIT
CONSTRUCTION CONTROLLED
FIRE

4.20

III-2.103 - Chart 2.0 - National Damage Limit

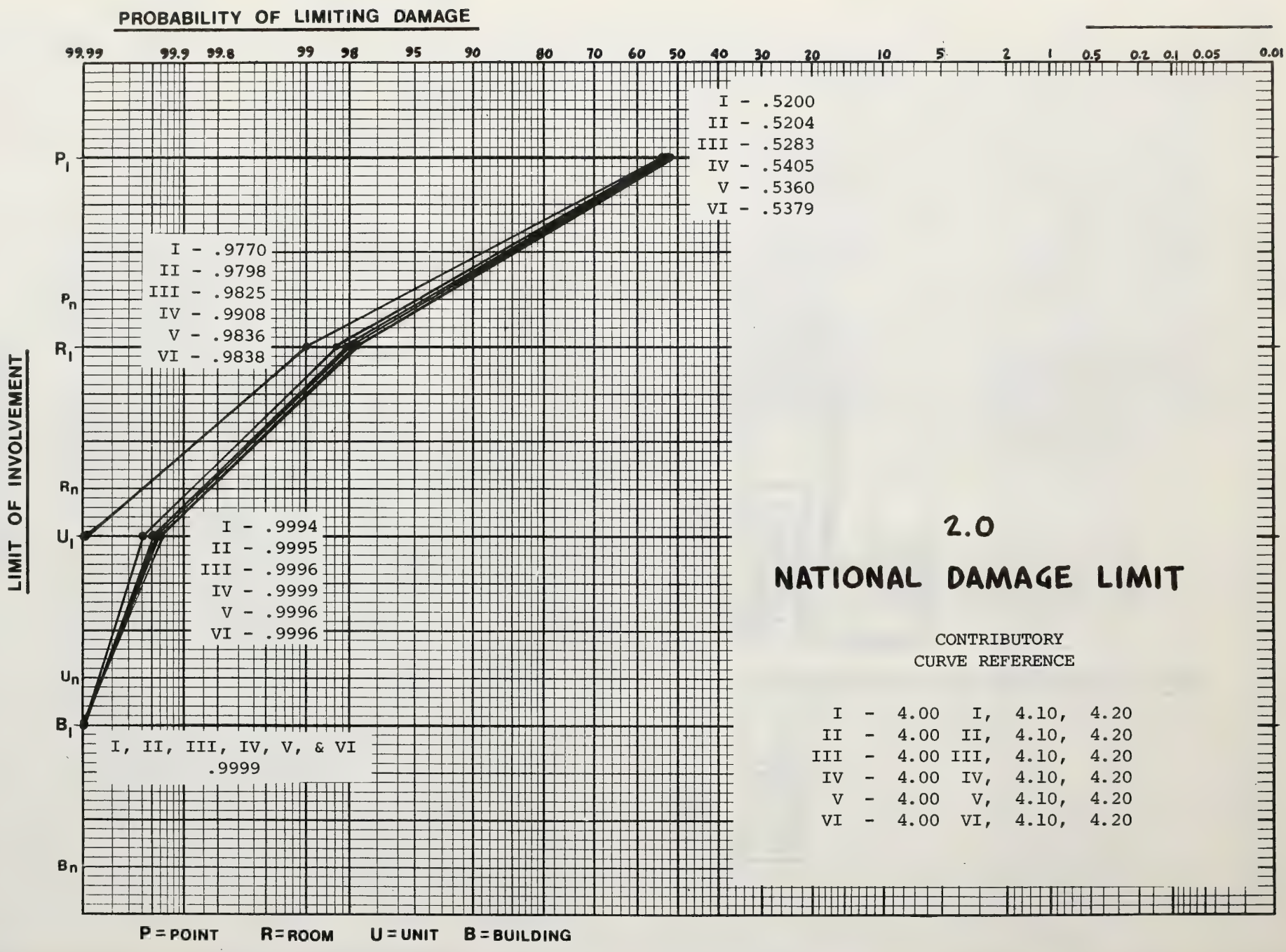
III-2.103.1 Chart 2.0 shows the probability of limiting total damage. It is the sum of the damage limits of fuel controlled fire, construction controlled fire and suppressed fire combined through an "OR" gate. It is an expression of the severity of residential fire.



III-2.103.2 By holding the input data (damage limits) from fuel controlled fire (Chart 4.10), construction controlled fire (Chart 4.20) and manually suppressed fire (Chart 4.02) constant, the effect of automatic sprinkler systems (Chart 4.01) on Chart 2.0 can be determined.

III-2.103.3 The curves shown on the chart represent:

- o Curve I - No system.
- o Curve II - Level I system installed on a voluntary basis.
- o Curve III - Level I system required in all new residential units (1990).
- o Curve IV - Level I system installed in all residential units (1990).
- o Curve V - Level II system required in all new residential units (1990).
- o Curve VI - Level III system required in all new residential units (1990).



2.0

NATIONAL DAMAGE LIMIT

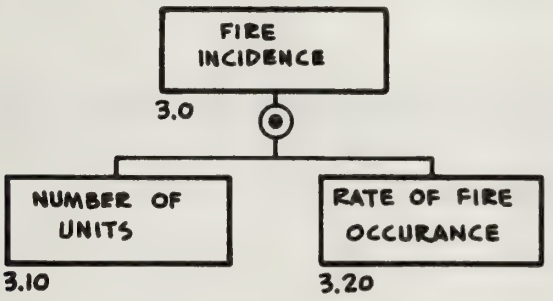
CONTRIBUTORY
CURVE REFERENCE

I	-	4.00	I, 4.10,	4.20
II	-	4.00	II, 4.10,	4.20
III	-	4.00	III, 4.10,	4.20
IV	-	4.00	IV, 4.10,	4.20
V	-	4.00	V, 4.10,	4.20
VI	-	4.00	VI, 4.10,	4.20

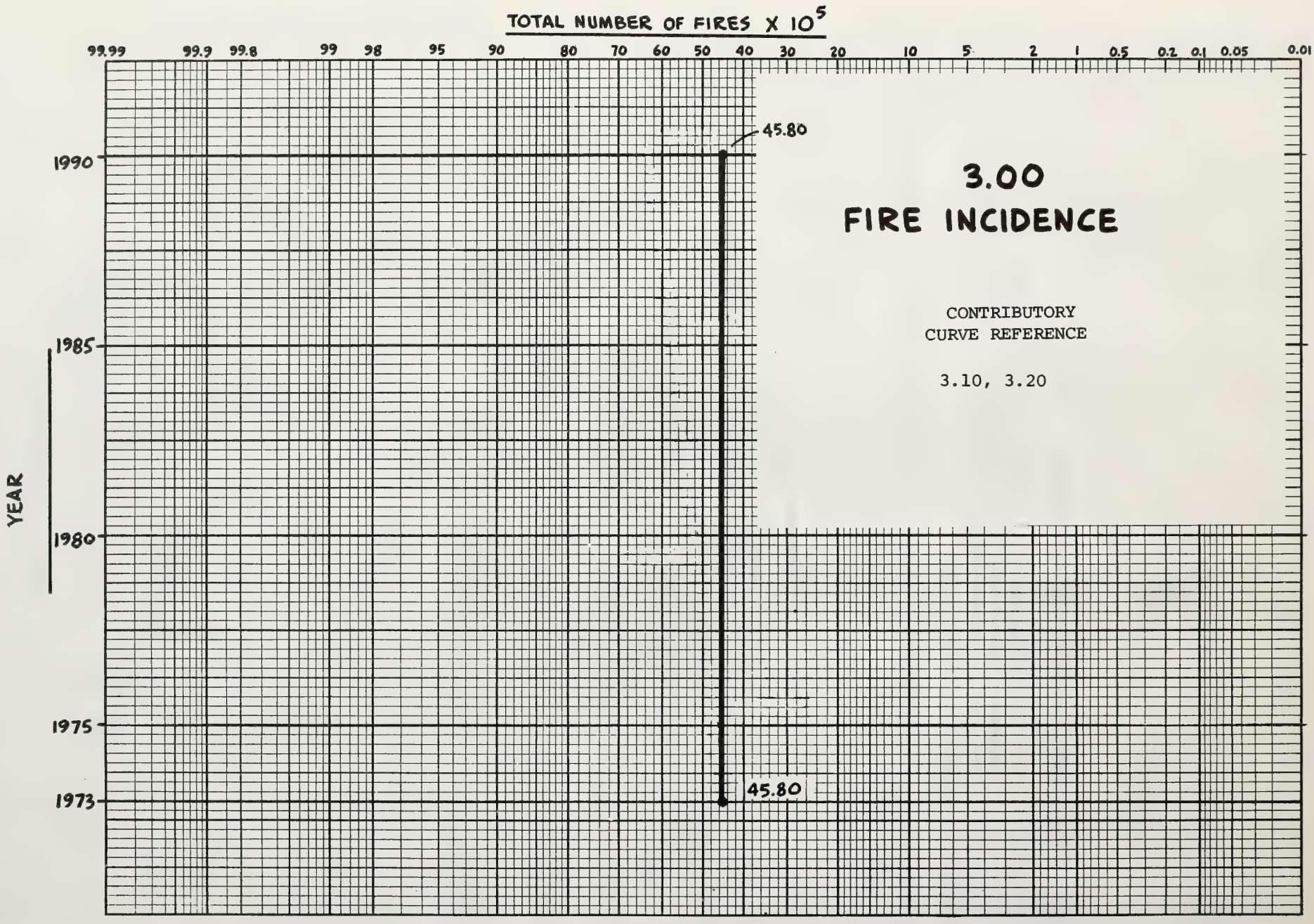
III-2.104 - Chart 3.0 - Fire Incidence

III-2.104.1 Chart 3.0 shows the annual number of fires as a function of time. The curve is the product of the number of exposed residential units times the rate of fire occurrence combined through an "AND" gate.

III-2.104.2 The number of fires occuring has been held constant for this analysis.

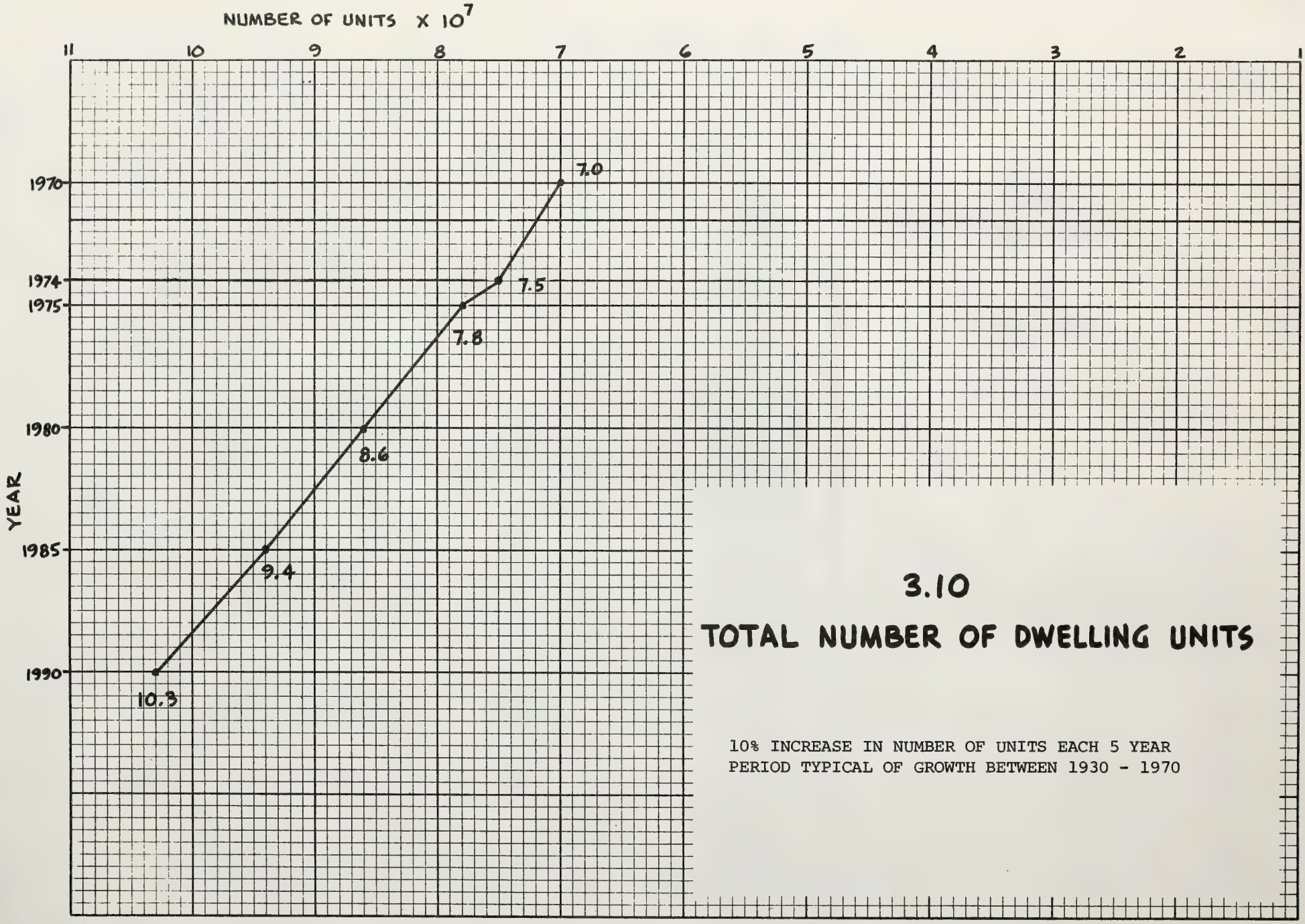


III-2.104.3 While Chart 2.0 expresses severity, Chart 3.0 expresses the frequency of fire occurrence.


TOTAL NUMBER OF FIRES X 10^5
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
45.80
1990
1985
1980
1975
1973
YEAR
45.80
3.00
FIRE INCIDENCE
CONTRIBUTORY
CURVE REFERENCE
3.10, 3.20

III-2.105 - Chart 3.10 - Total Number of Dwelling Units

Chart 3.10 shows the projected total number of dwelling units in the country as a function of time. The curve was developed based upon an increase in the number of residential units of 10% during each five year period. This growth rate is typical of the growth rate between the years 1930 and 1970.



3.10

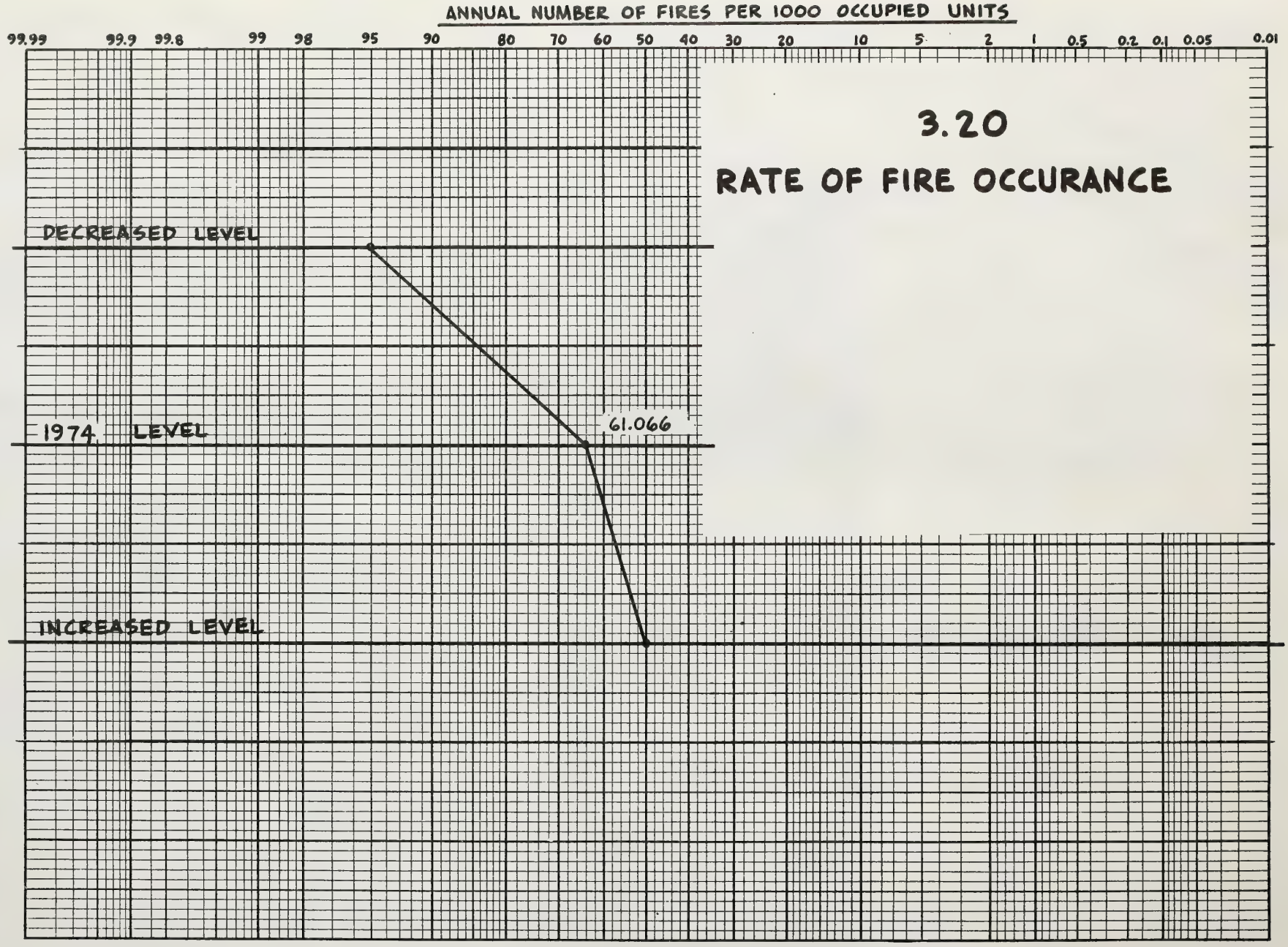
TOTAL NUMBER OF DWELLING UNITS

10% INCREASE IN NUMBER OF UNITS EACH 5 YEAR PERIOD TYPICAL OF GROWTH BETWEEN 1930 - 1970

III-2.106 - Chart 3.20 - Rate of Fire Occurrence

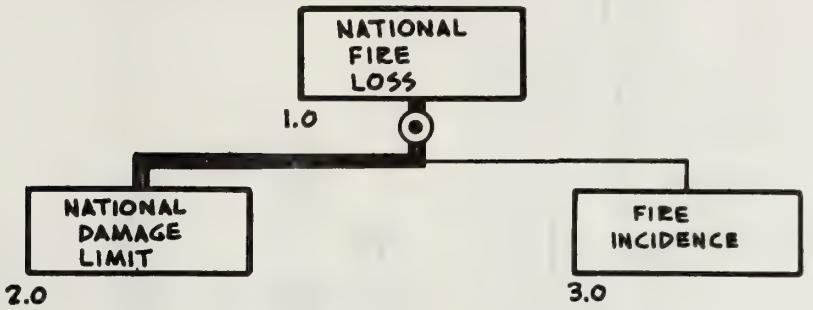
III-2.106.1 Chart 3.20 shows the rate of fire occurrence in terms of the number of fires per thousand residential units.

III-2.106.2 The rate of fire occurrence is a sociological phenomenon, related to such divergent items as energy conservation, the state of the nation's economy, the population density in an area, the type of furnishing materials used, the weather, the attitude of the American people towards fire, etc. The rate of fire occurance is considered indeterminate for this analysis. This will enable the total number of fires (Chart 3.0) to be held constant.


ANNUAL NUMBER OF FIRES PER 1000 OCCUPIED UNITS
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
3.20
RATE OF FIRE OCCURANCE
DECREASED LEVEL
1974 LEVEL
61.066
INCREASED LEVEL
FIRE CONCERN OF NATION

III-2.107 - Chart 1.0 - National Fire Loss

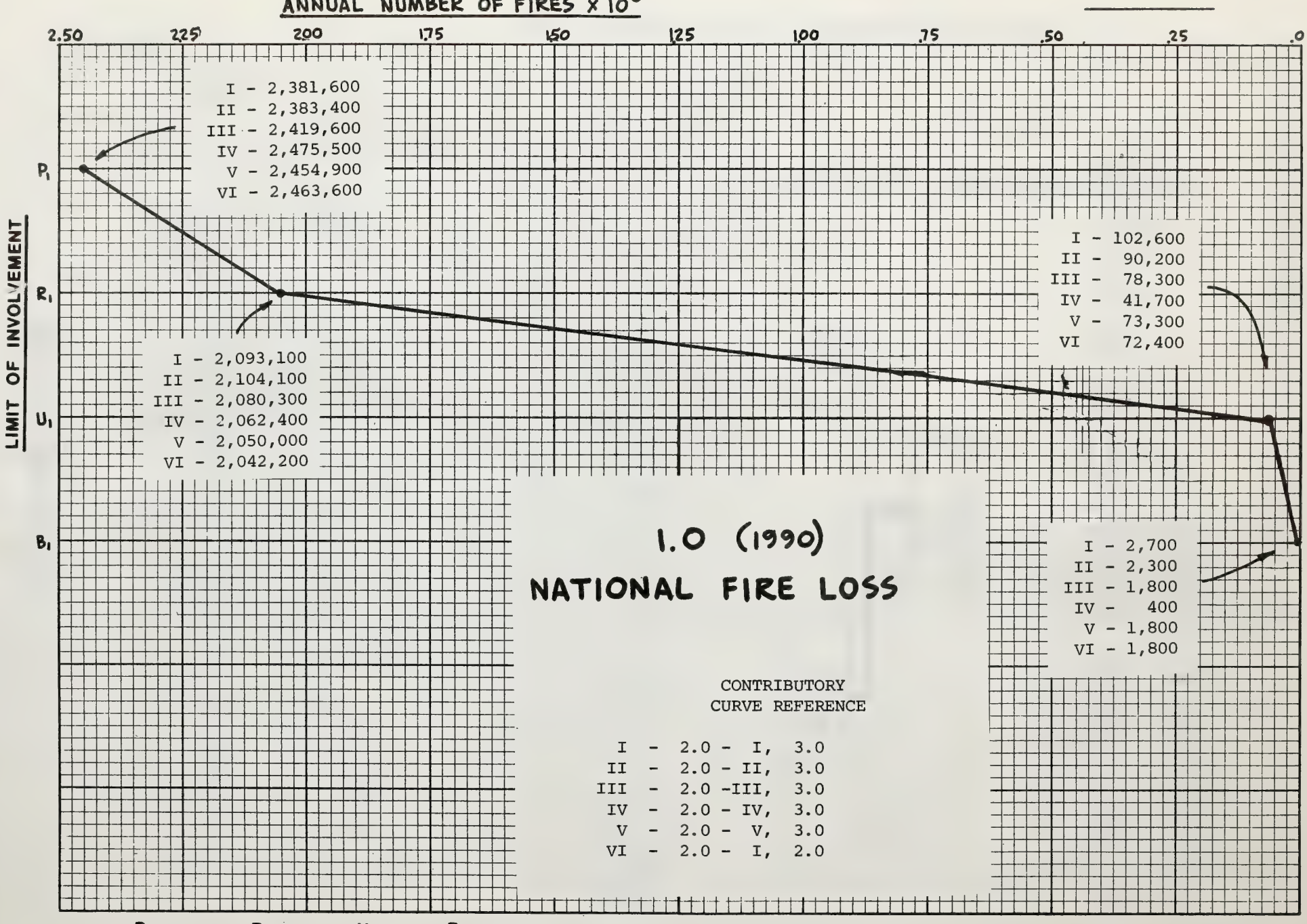
III-2.107.1 Chart 1.0 shows the projected National Residential Fire Loss (Property). It is the product of the fire severity and the fire frequency combined through an "AND" gate.



III-2.107.2 The curves are expressed as the number of fires which will have the damage limited within referenced boundaries. The actual dollar loss to property caused by residential fire is calculated in Chapter 4 (4-6.1).

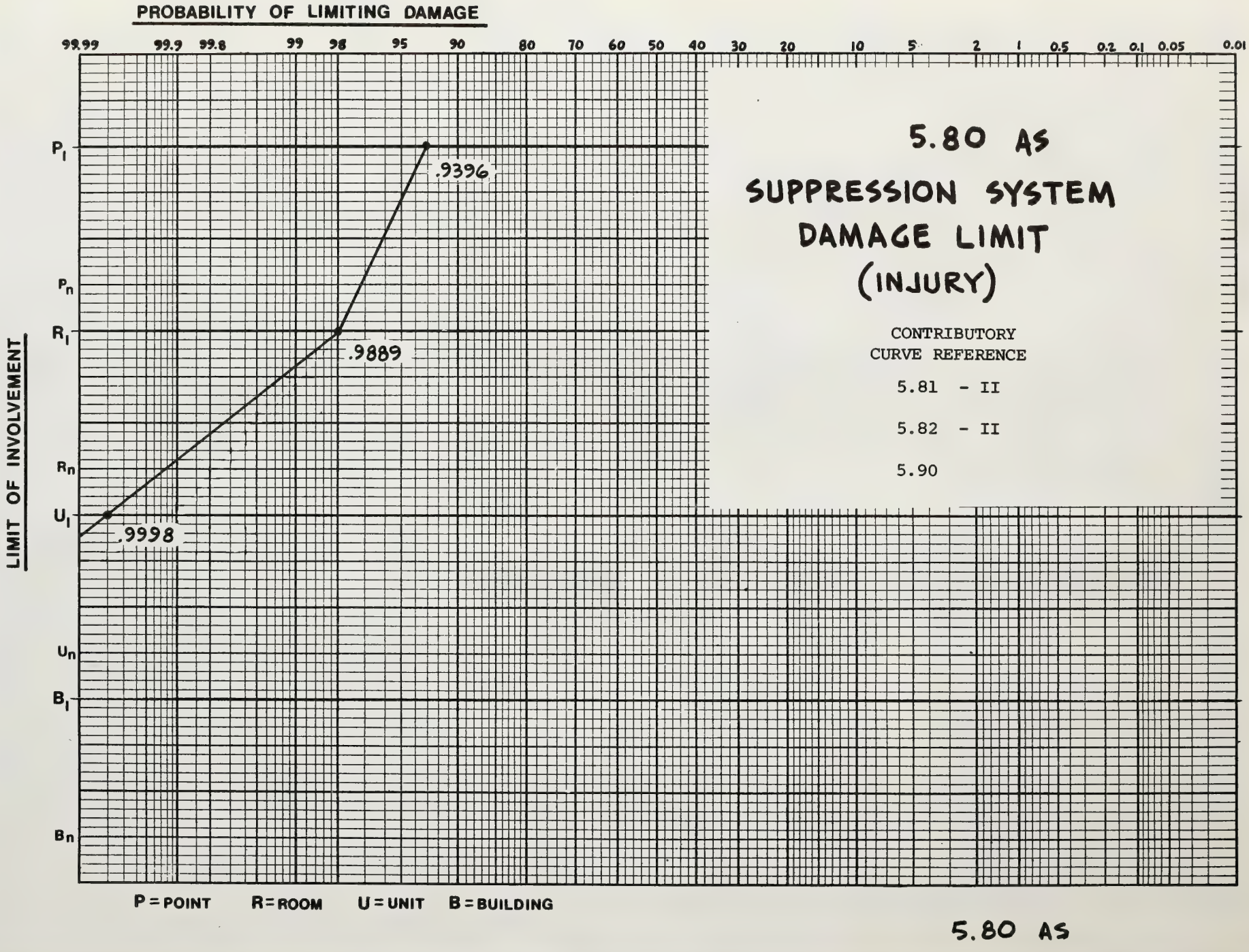
III-2.107.3 The curves shown on the chart represent:

- o Curve I - No system.
- o Curve II - Level 1 system installed on a voluntary basis.
- o Curve III - Level 1 system required in all new residential units (1990).
- o Curve IV - Level 1 system installed in all residential units (1990).
- o Curve V - Level II system required in all new residential units (1990).
- o Curve VI - Level III system required in all new residential units (1990).


ANNUAL NUMBER OF FIRES x 10⁶
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
.25
.0
LIMIT OF INVOLVEMENT
P₁
R₁
U₁
B₁
I - 2,381,600
II - 2,383,400
III - 2,419,600
IV - 2,475,500
V - 2,454,900
VI - 2,463,600
I - 2,093,100
II - 2,104,100
III - 2,080,300
IV - 2,062,400
V - 2,050,000
VI - 2,042,200
I - 102,600
II - 90,200
III - 78,300
IV - 41,700
V - 73,300
VI 72,400
I - 2,700
II - 2,300
III - 1,800
IV - 400
V - 1,800
VI - 1,800
1.0 (1990)
NATIONAL FIRE LOSS
CONTRIBUTORY
CURVE REFERENCE
I - 2.0 - I, 3.0
II - 2.0 - II, 3.0
III - 2.0 -III, 3.0
IV - 2.0 - IV, 3.0
V - 2.0 - V, 3.0
VI - 2.0 - I, 2.0
P = POINT R = ROOM U = UNIT B = BUILDING

1.0

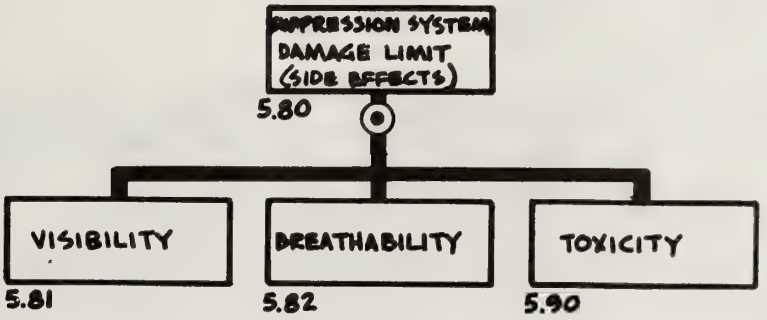
III-3 Injury Loss - Discussion

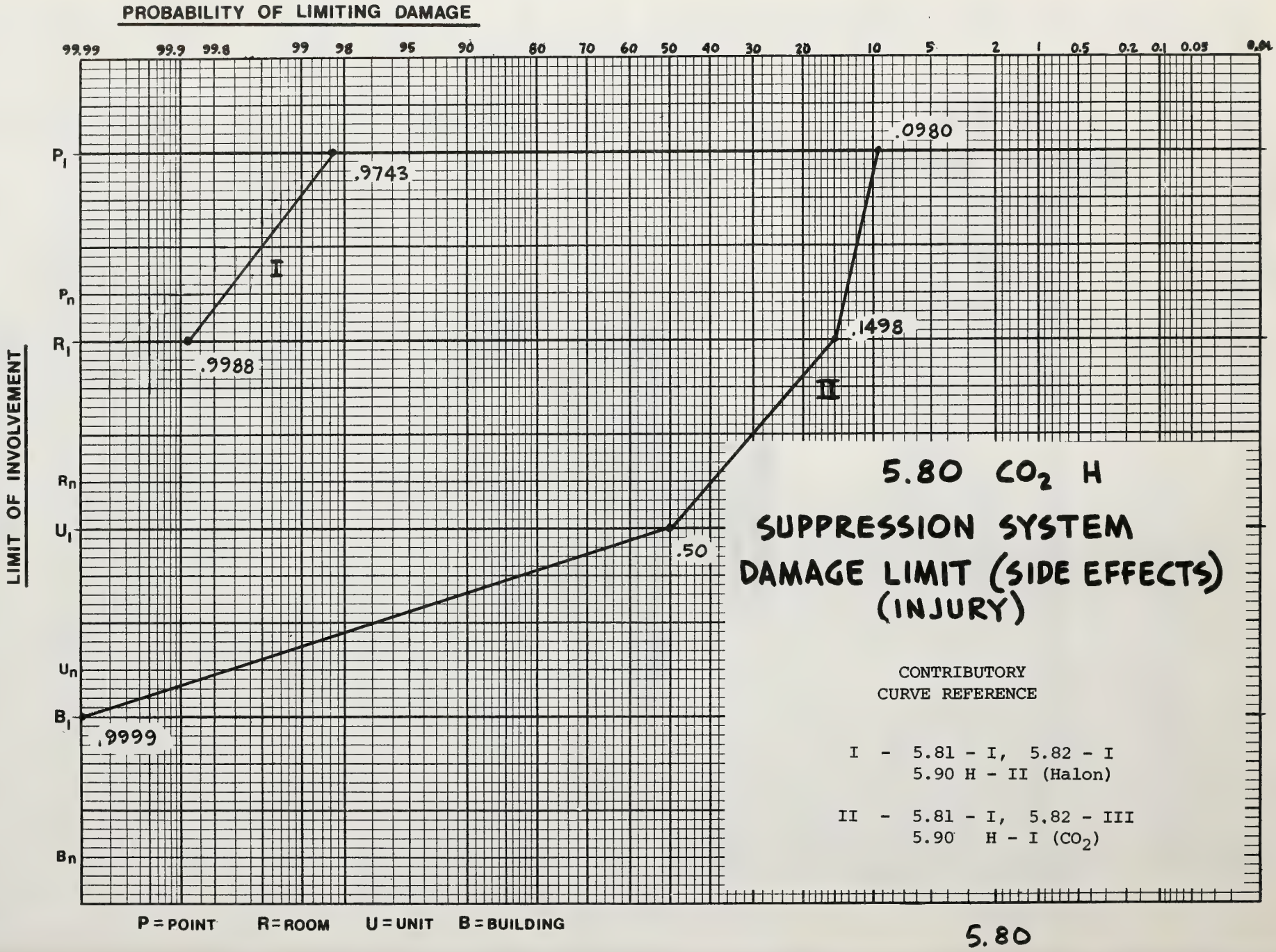

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9396
.9889
.9998
5.80 AS
SUPPRESSION SYSTEM
DAMAGE LIMIT
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
5.81 - II
5.82 - II
5.90
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.80 AS

III-3.1 - Chart 5.80-AS Suppression System Damage Limit Side Effects

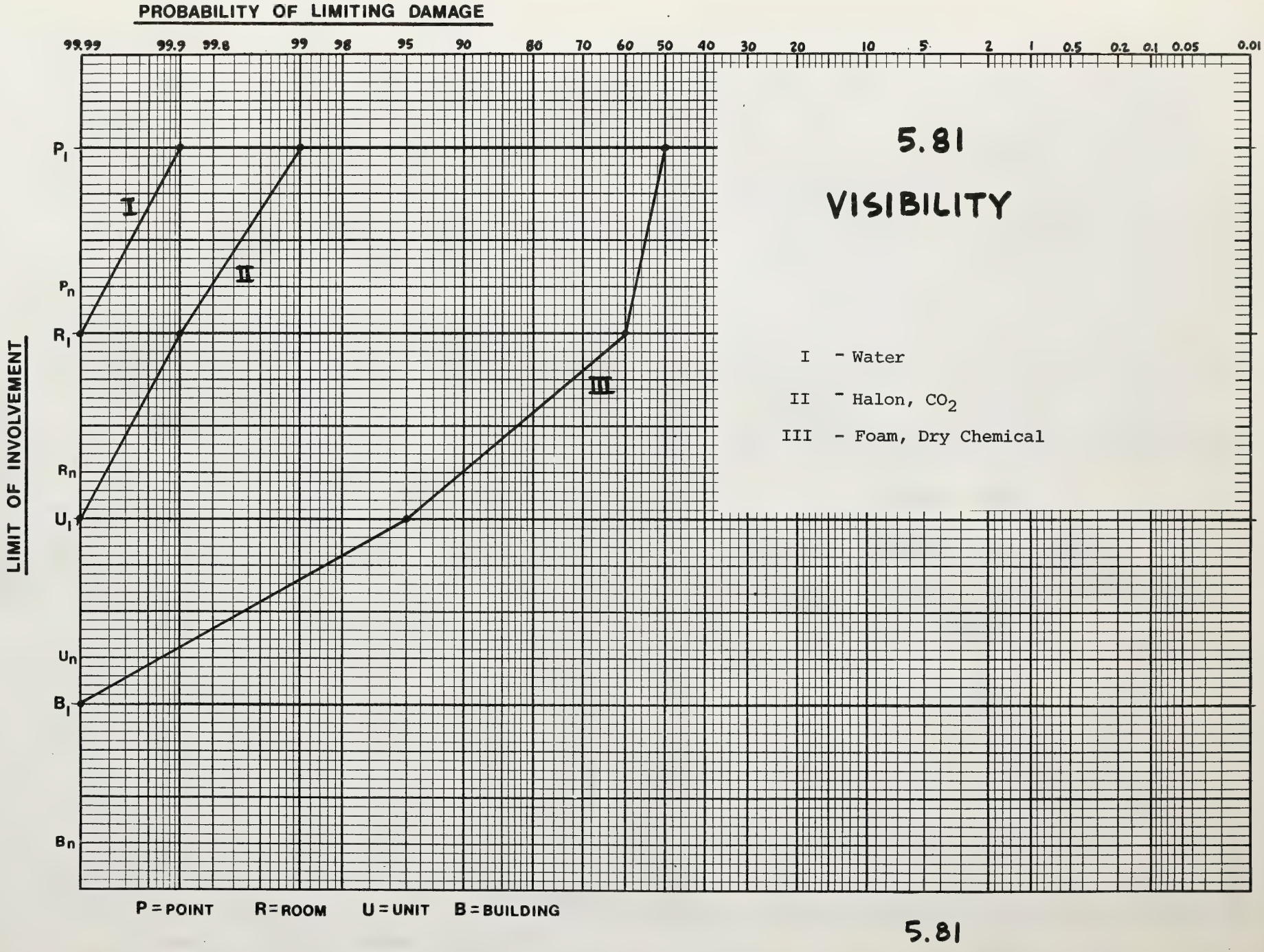
Chart 5.80-AS shows the probability of limiting side effects damage as it affects human safety (Chart 5.60 shows side effects damage as it affects property). The curve is the product of the visibility during system discharge, the breathability during system discharge and the toxicity of the environment during discharge combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0980
.9743
.1498
.9988
.50
.9999
I
II
5.80 CO2 H
SUPPRESSION SYSTEM
DAMAGE LIMIT (SIDE EFFECTS)
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
I - 5.81 - I, 5.82 - I
5.90 H - II (Halon)
II - 5.81 - I, 5.82 - III
5.90 H - I (CO2)
P = POINT
R = ROOM
U = UNIT
B = BUILDING

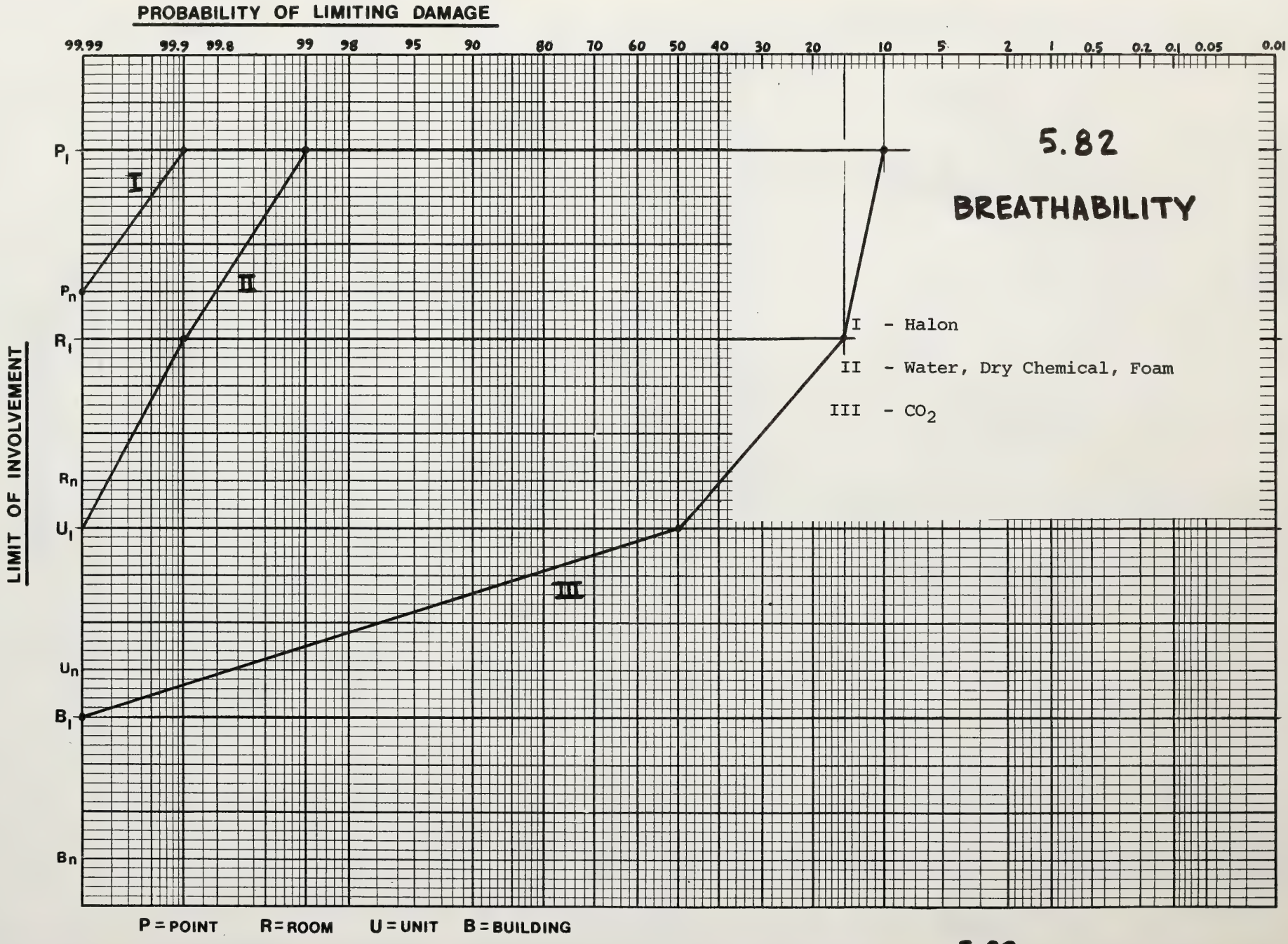
III.3.2 - Chart 5.80-CO2, H Suppression System Damage Limit Side Effects

Chart 5.80-CO2, H shows the side effects damage for halon and carbon dioxide systems. The chart shows a definite increase in the human damage potential caused by carbon dioxide systems as compared to either the sprinkler system or the halon system.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.81
VISIBILITY
I - Water
II - Halon, CO2
III - Foam, Dry Chemical
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.3 - Chart 5.81 - Visibility

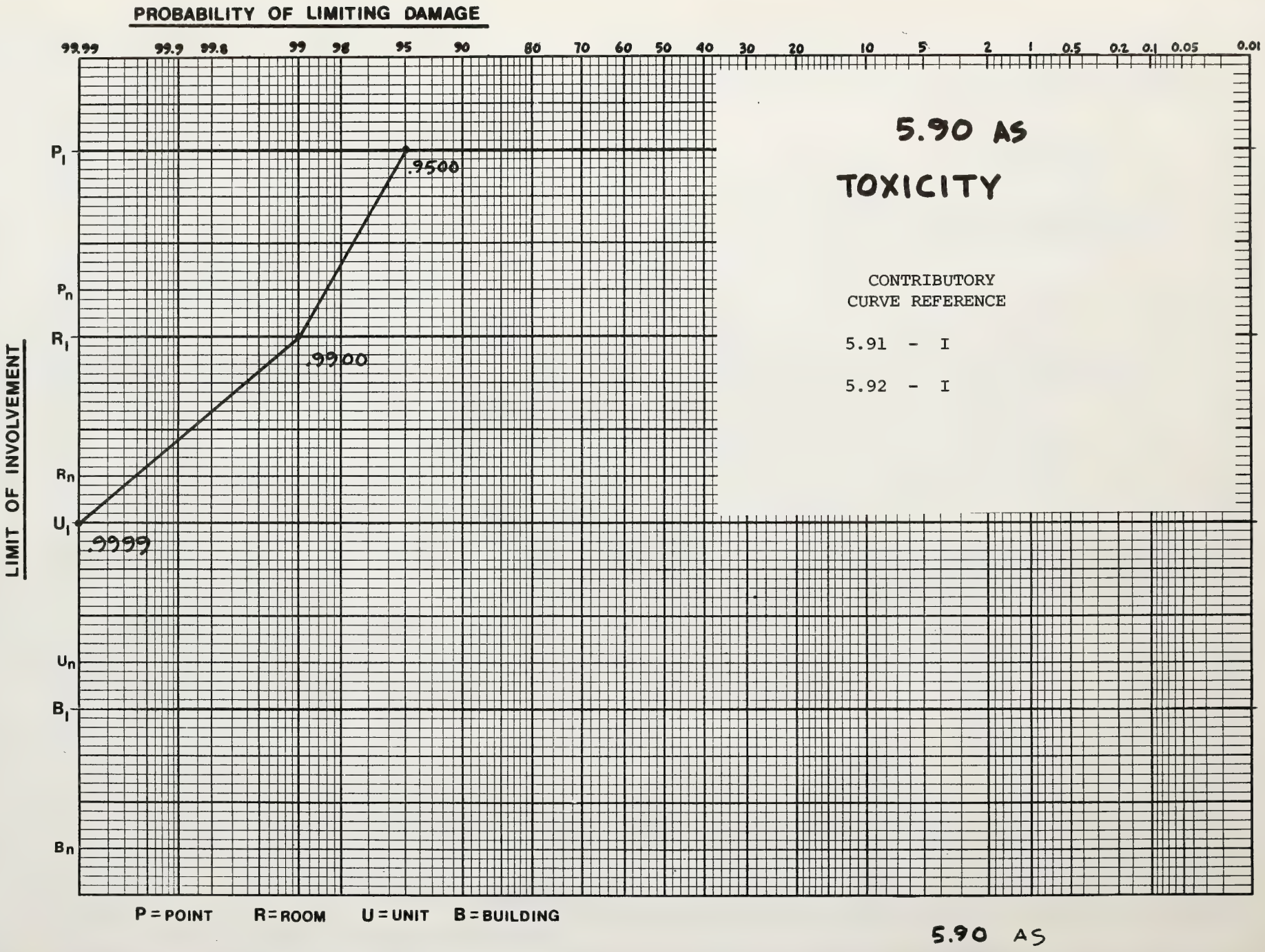
Chart 5.81 shows the effect of the agent discharge on limiting visibility. The curves are based on judgment, considering fire research data and fire records.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I
II
III
5.82
BREATHABILITY
I - Halon
II - Water, Dry Chemical, Foam
III - CO_2
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.4 - Chart 5.82 - Breathability

III-3.4.1 Chart 5.82 shows the effect of agent discharge on breathability. The curves are based on judgment, considering fire research data and fire records.

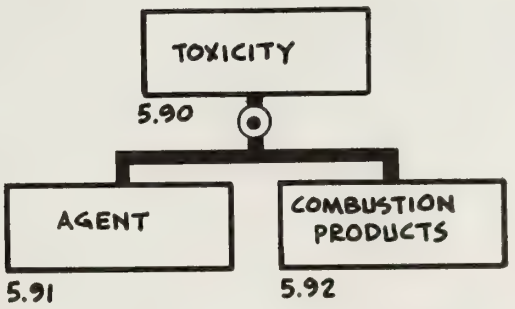
III-3.4.2 Carbon dioxide creates an unbreathable atmosphere in the area of the fire when it discharges in sufficient quantity to effect extinguishment.

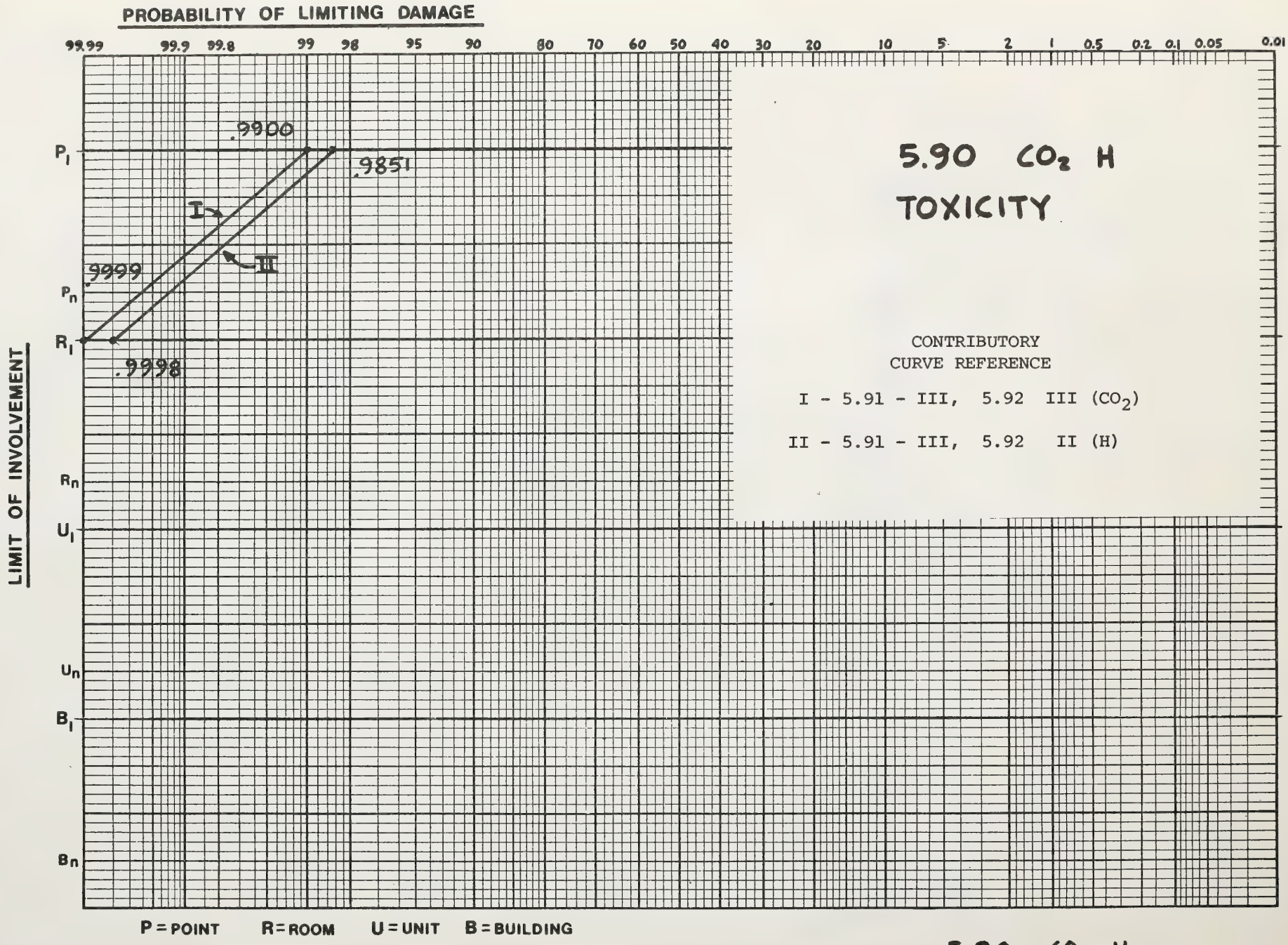

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9500
.9900
.9999
5.90 AS
TOXICITY
CONTRIBUTORY
CURVE REFERENCE
5.91 - I
5.92 - I
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.90 AS

III.3.5 - Chart 5.90-AS Toxicity

Chart 5.90-AS represents the toxicity created during sprinkler system discharge. It is the product of the agent toxicity and the increased toxicity of combustion products during discharge combined through an "AND" gate.

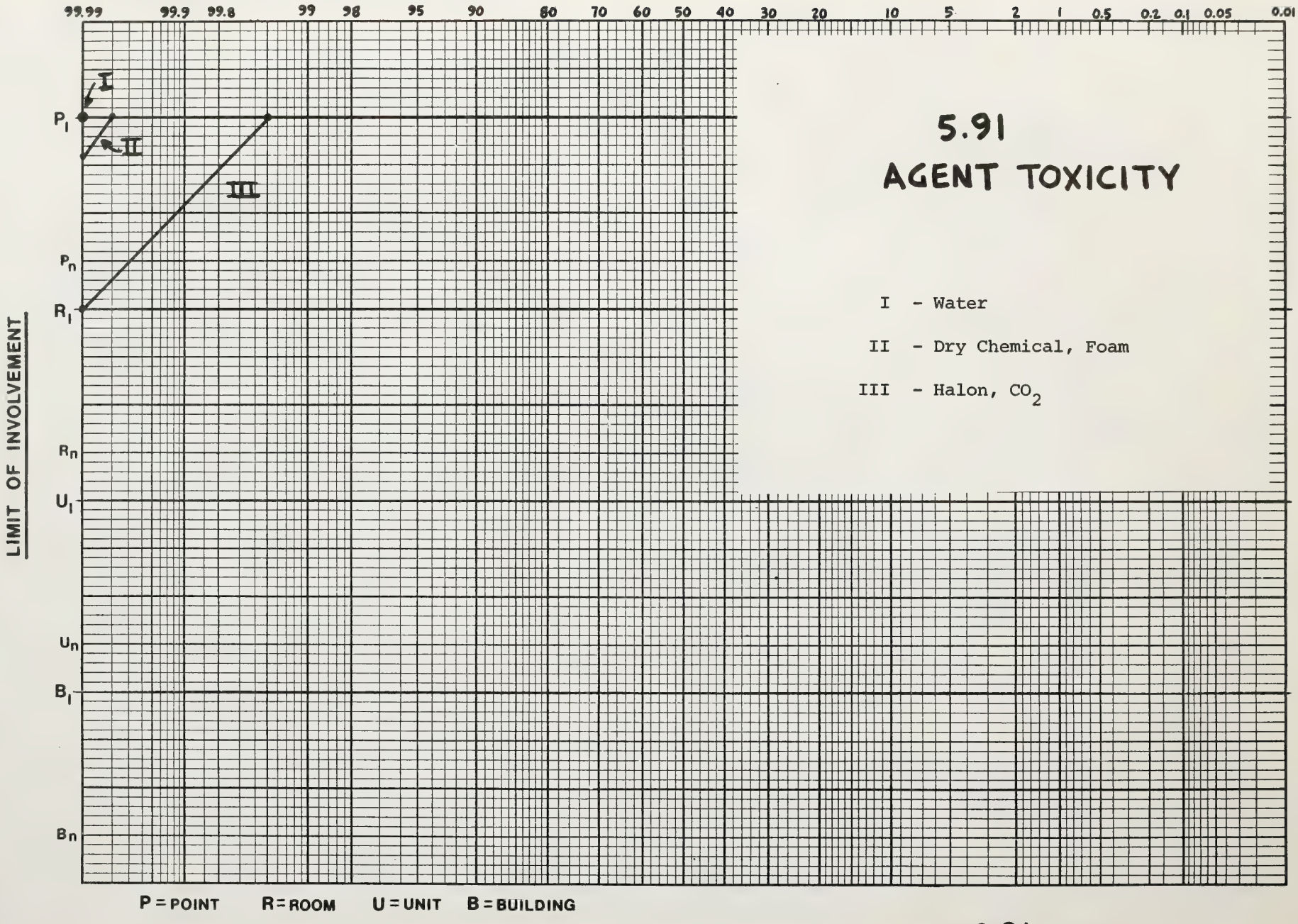



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9900
.9851
.9999
.9998
I
II
5.90 CO2 H
TOXICITY
CONTRIBUTORY
CURVE REFERENCE
I - 5.91 - III, 5.92 III (CO2)
II - 5.91 - III, 5.92 II (H)
P = POINT
R = ROOM
U = UNIT
B = BUILDING

5.90 CO_2 H

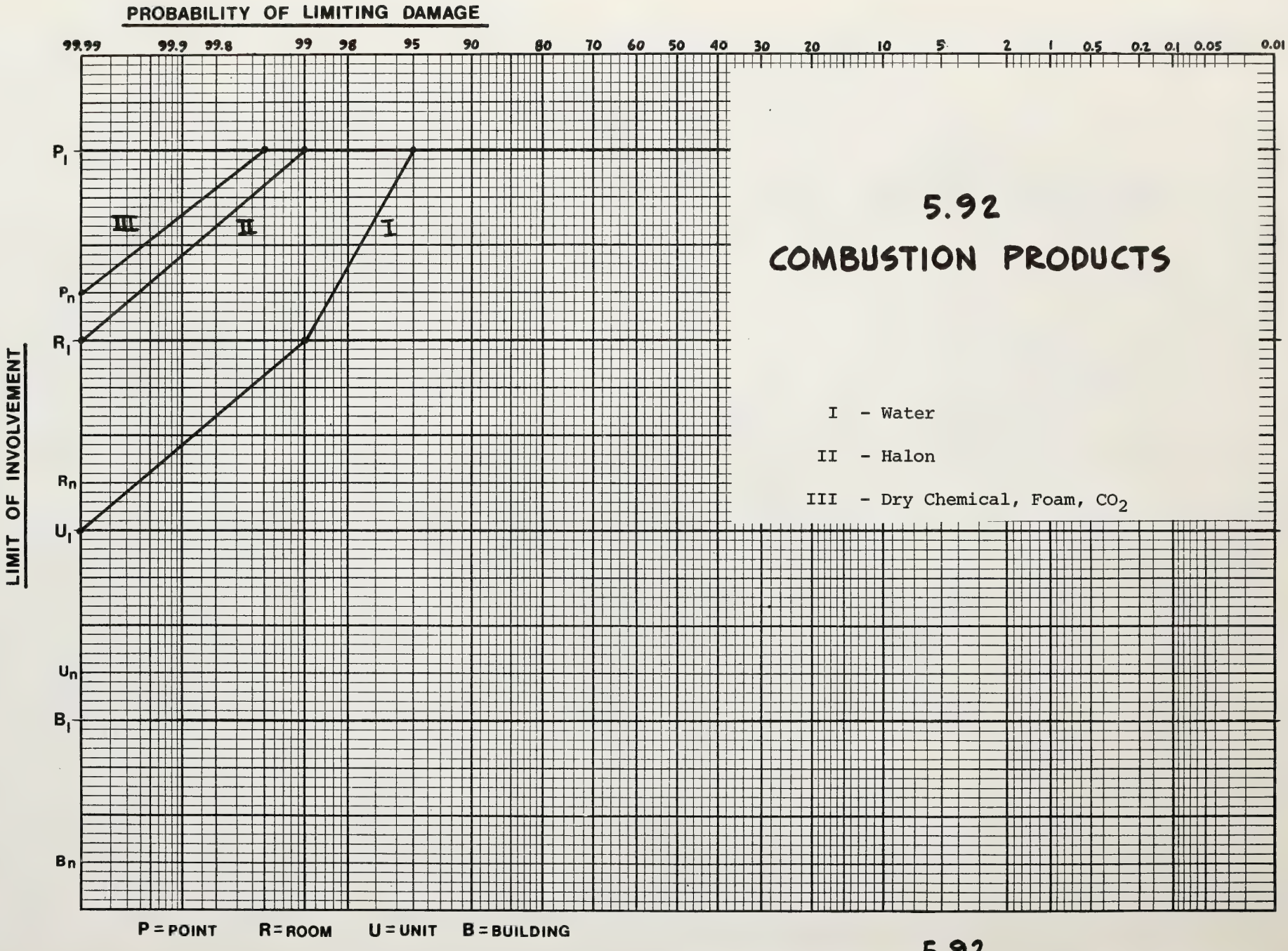
III-3.6 - Chart 5.90-CO2, H Toxicity

Chart 5.90-CO2, H represents the toxicity of carbon dioxide and halon during discharge. The curve is based on judgment, considering fire research data and fire records.


PROBABILITY OF LIMITING FIRE DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I
II
III
5.91
AGENT TOXICITY
I - Water
II - Dry Chemical, Foam
III - Halon, CO2
P = POINT
R = ROOM
U = UNIT
B = BUILDING

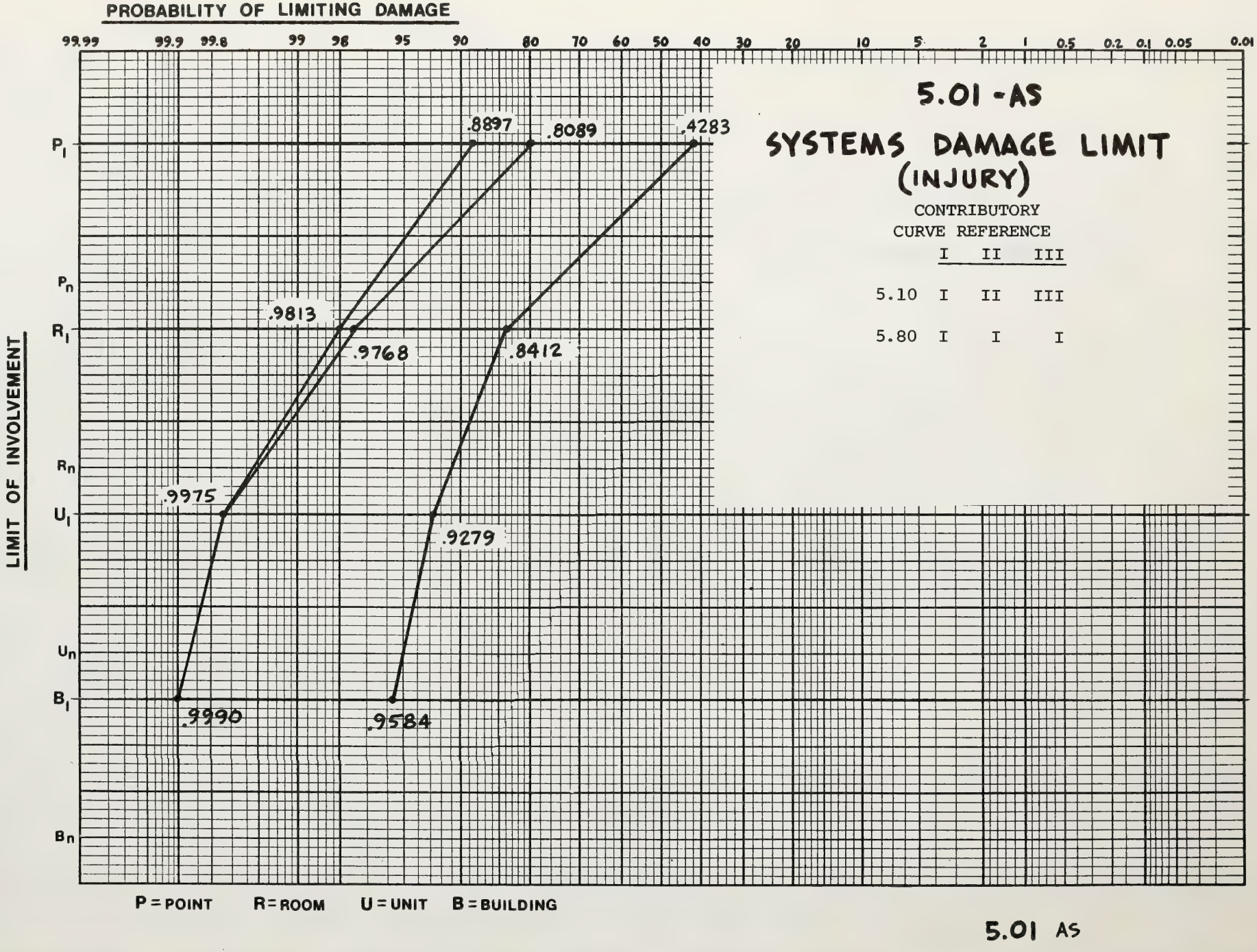
III-3.7 - Chart 5.91 - Agent Toxicity

Chart 5.91 shows the toxicity of the extinguishing agent during discharge. The curve is based on judgment, considering fire research data and fire records.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
III
II
I
5.92
COMBUSTION PRODUCTS
I - Water
II - Halon
III - Dry Chemical, Foam, CO_2
P = POINT
R = ROOM
U = UNIT
B = BUILDING

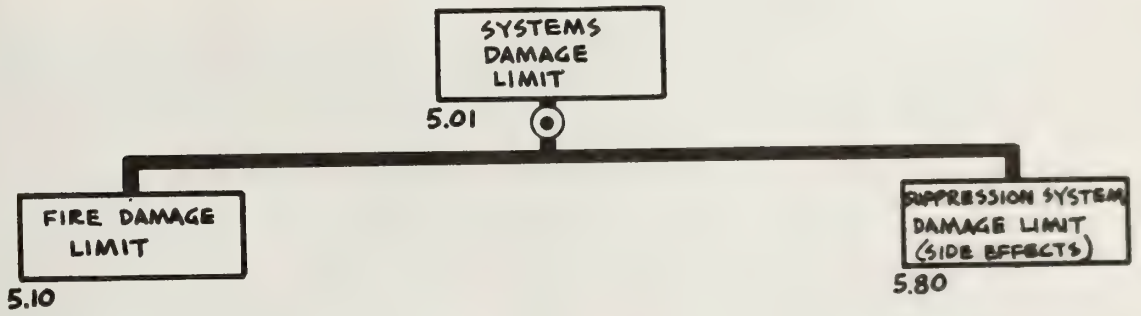
III-3.8 - Chart 5.92 - Combustion Products

Chart 5.92 represents the increase in toxicity of the combustion products created during the system discharge.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.8897
.8089
.4283
.9813
.9768
.8412
.9975
.9279
.9990
.9584
5.01 -AS
SYSTEMS DAMAGE LIMIT
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
I II III
5.10 I II III
5.80 I I I
P = POINT R = ROOM U = UNIT B = BUILDING

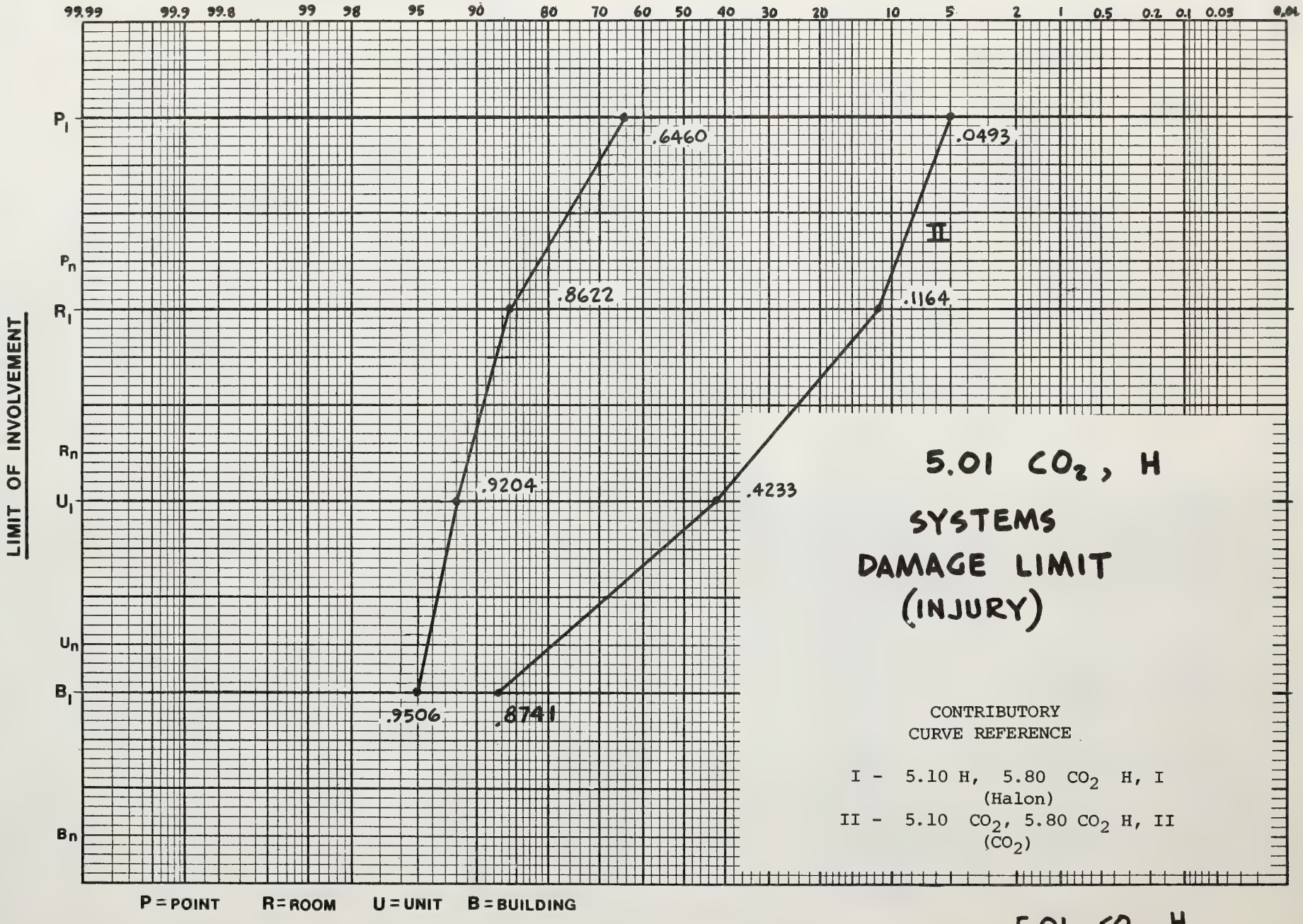
III-3.9 - Chart 5.01-AS Systems Damage Limit

III-3.9.1 Chart 5.01-AS is analogous to Chart 5.0-AS. It shows the ability of an automatic suppression system to limit human damage (Chart 5.0-AS shows the system's ability to limit property damage). Chart 5.01 - AS is the product of the fire damage limit and the suppression system damage limit combined through an "AND" gate.



III-3.9.2

- Curve I represents a level I system;
- Curve II a level II system;
- Curve III, a level III system.

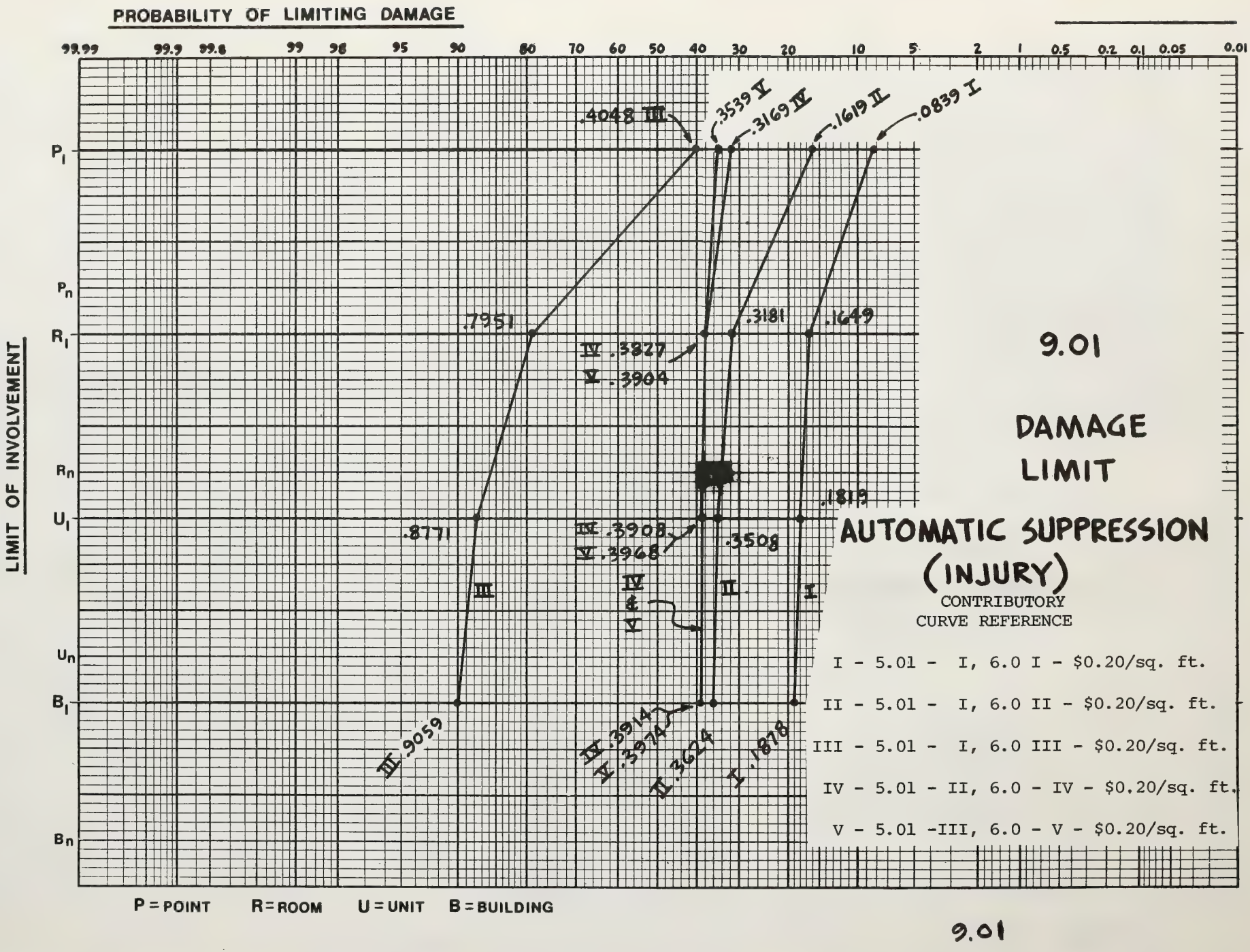

PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.6460
.0493
II
.8622
.1164
.9204
.4233
.9506
.8741
5.01 CO2, H
SYSTEMS
DAMAGE LIMIT
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
I - 5.10 H, 5.80 CO2 H, I
(Halon)
II - 5.10 CO2, 5.80 CO2 H, II
(CO2)
P = POINT R = ROOM U = UNIT B = BUILDING

5.01 CO_2, H

III-3.10 - Chart 5.01-CO2, H Systems Damage Limit

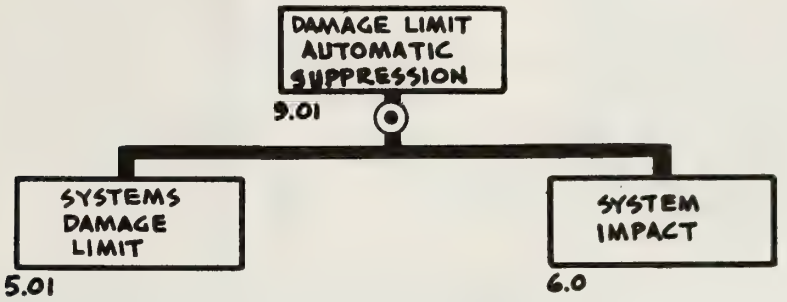
III-3.10.1 Chart 5.01-CO2, H shows that the Halon system may be comparable to the sprinkler system in limiting the human damage potential of a residential fire.

III-3.10.2 This chart also shows that carbon dioxide systems are considerably less capable in limiting a fire's human damage potential. As a result of this analysis, carbon dioxide systems are considered not suitable for use in a residential occupancy.


PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.4048 III
.3539 V
.3169 IV
.1619 II
.0839 I
.7951
.3181
.1649
IV .3827
V .3904
.8771
IV .3908
V .3968
.3508
.1813
III .9059
IV .3914
V .3974
V .3624
I .1878
9.01
DAMAGE LIMIT
AUTOMATIC SUPPRESSION (INJURY)
CONTRIBUTORY CURVE REFERENCE
I - 5.01 - I, 6.0 I - $0.20/sq. ft.
II - 5.01 - I, 6.0 II - $0.20/sq. ft.
III - 5.01 - I, 6.0 III - $0.20/sq. ft.
IV - 5.01 - II, 6.0 - IV - $0.20/sq. ft.
V - 5.01 -III, 6.0 - V - $0.20/sq. ft.
P = POINT R = ROOM U = UNIT B = BUILDING

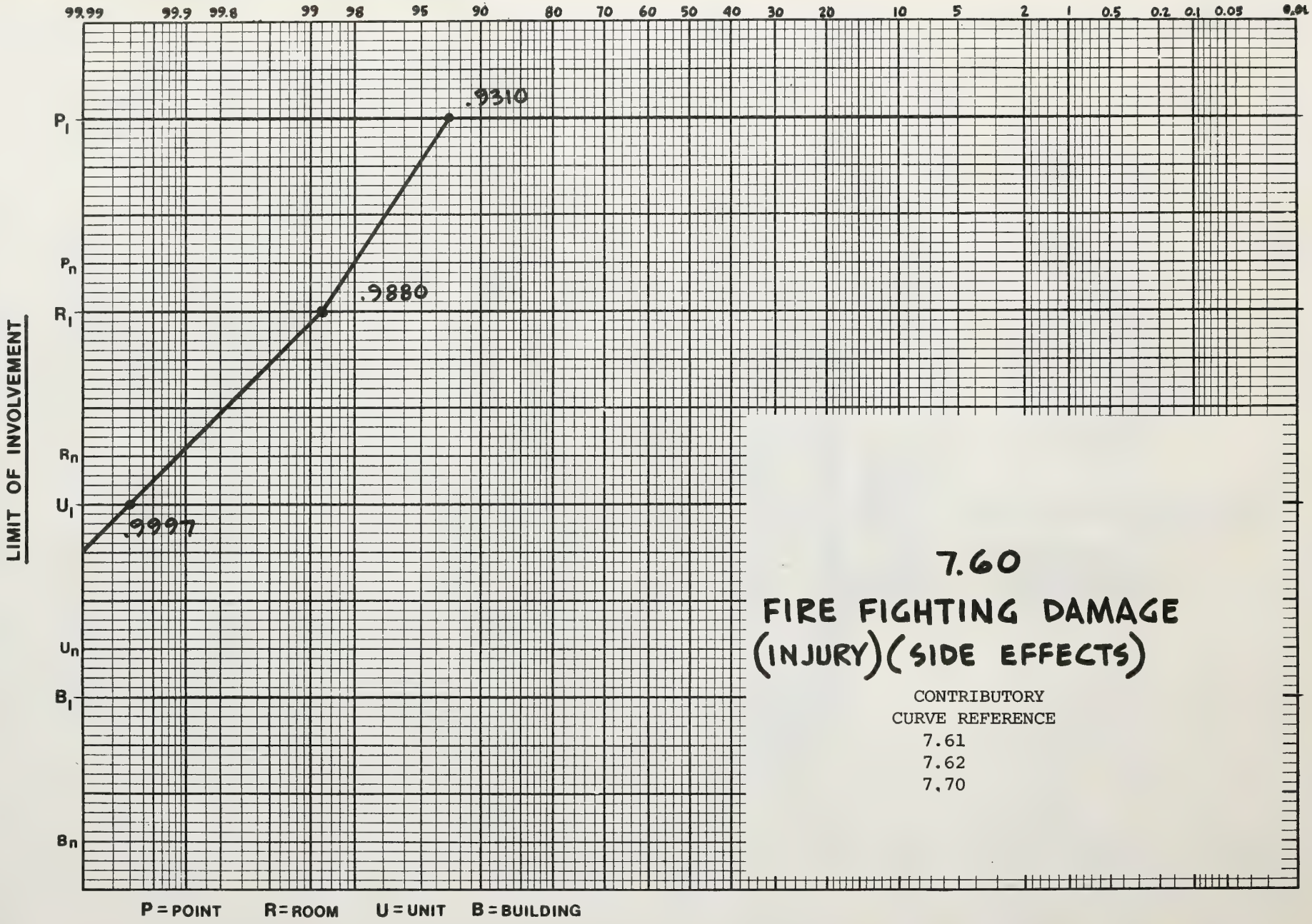
III-3.11 - Chart 9.01 - Damage Limit Automatic Suppression

III-3.11.1 Chart 9.01 shows the ability of an automatic sprinkler system to limit the human damage potential of residential fire on a national basis. It is the product of the ability of the system to limit damage and the utilization of the system combined through an "AND" gate.



III-3.11.2

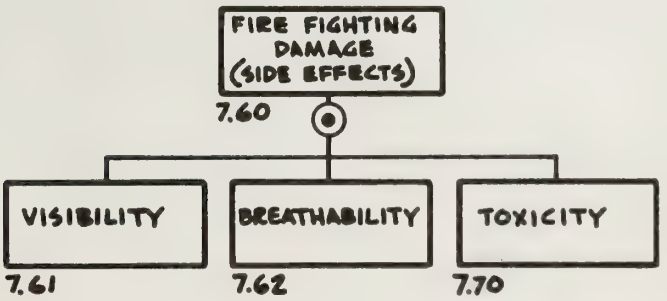
- Curve 1 represents the voluntary use of a Level I system available at the target cost of $0.20/sq.ft.
- Curve II represents the use of a Level I system which is required by law in all new residential units and available at a cost of $0.20/sq.ft.
- Curve III represents the use of a Level I system installed in all residential units.
- Curve IV represents the use of a Level II system which is required to be installed in all new residential units and available at a cost of $0.20/sq.ft.
- Curve V represents the use of a Level III system which is also required to be installed in all new residential units and available at a cost of $0.20/sq.ft.

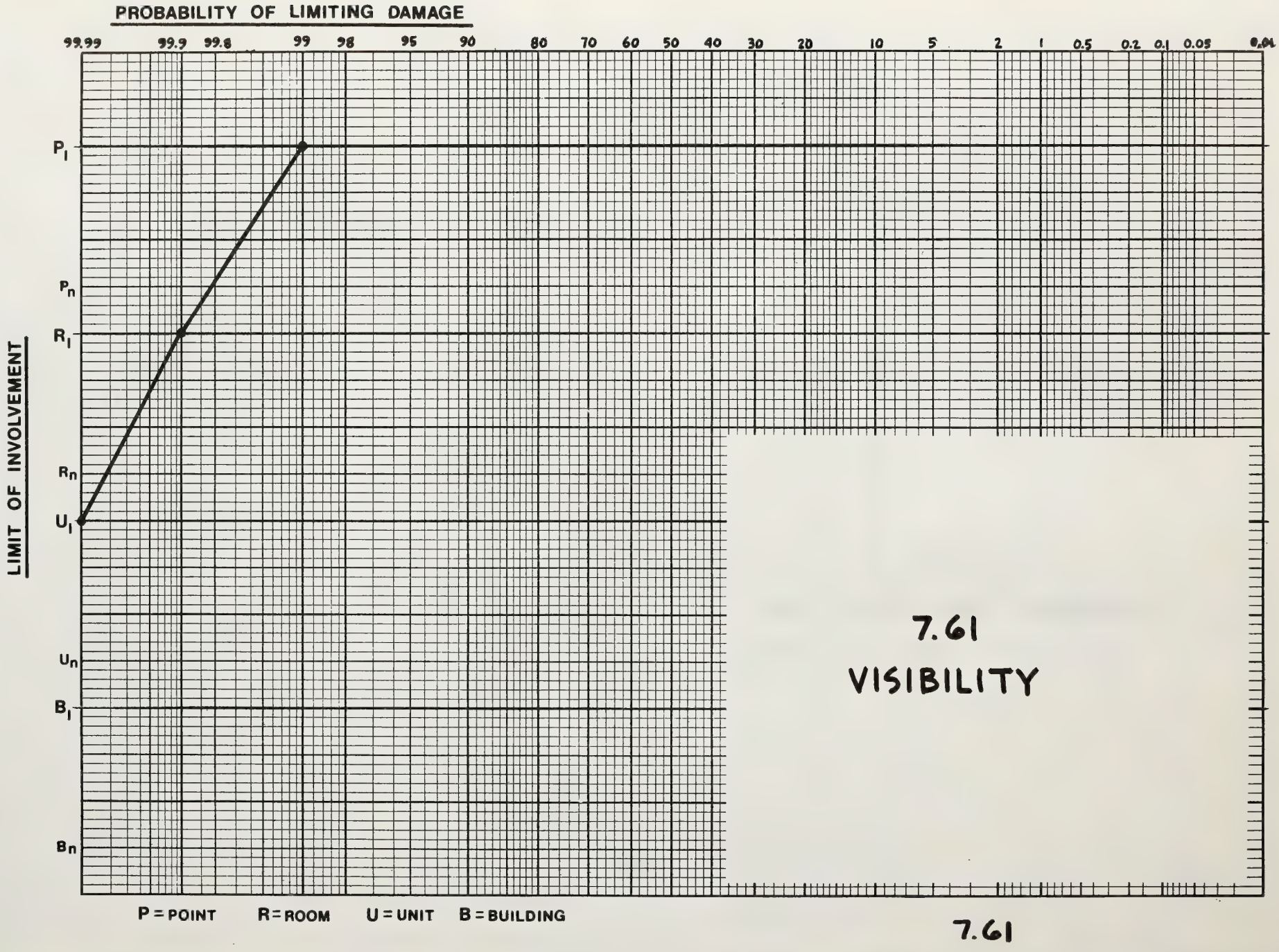

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.9310
.9880
.9997
7.60
FIRE FIGHTING DAMAGE
(INJURY)(SIDE EFFECTS)
CONTRIBUTORY
CURVE REFERENCE
7.61
7.62
7.70
P = POINT
R = ROOM
U = UNIT
B = BUILDING

7.60

III-3.12 - Chart 7.60 - Fire Fighting Damage Side Effects

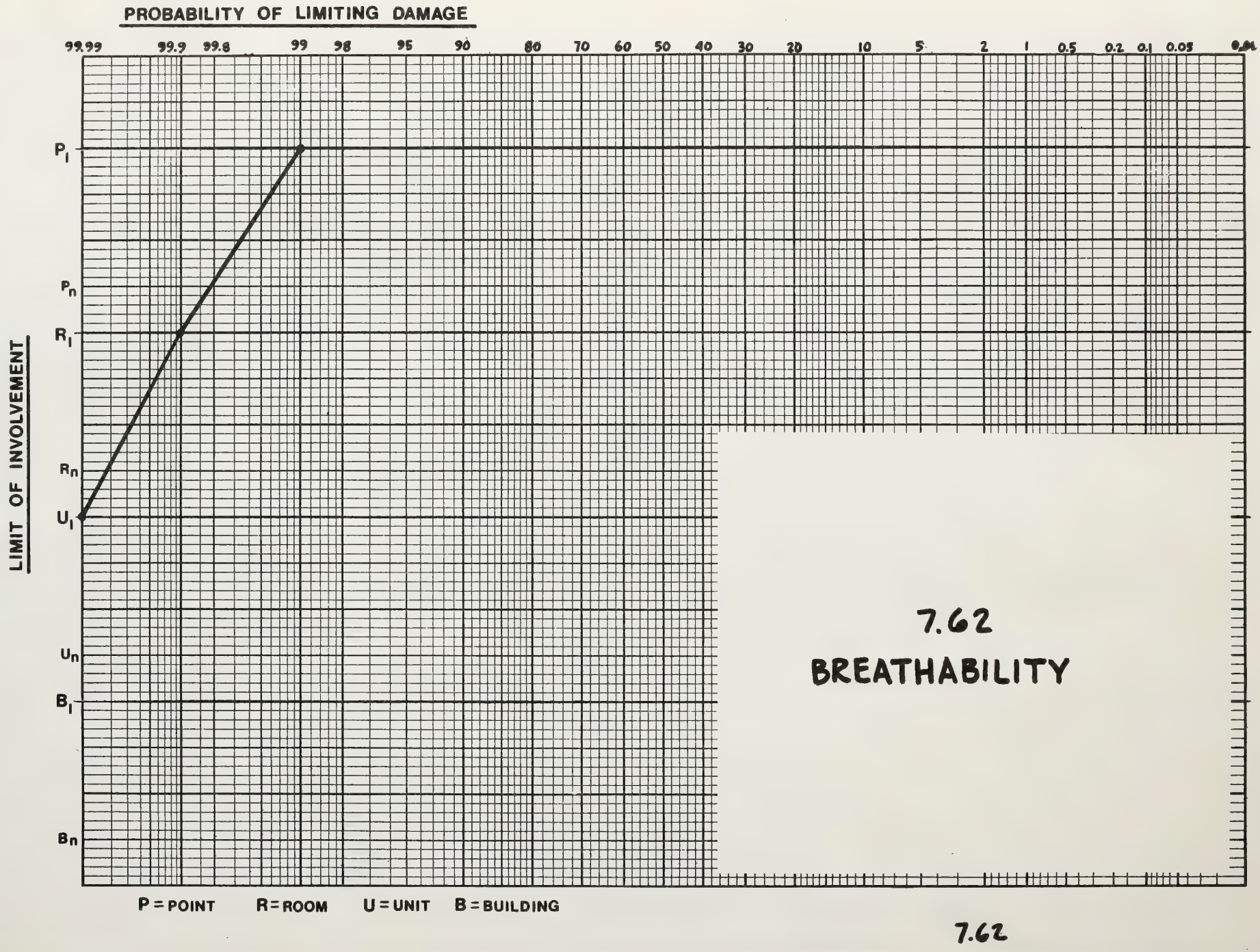
Chart 7.60 represents the ability of manual fire fighting to limit human damage during the extinguishing process. This curve is a composite of the visibility, breathability and toxicity occurring during extinguishment combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.61
VISIBILITY

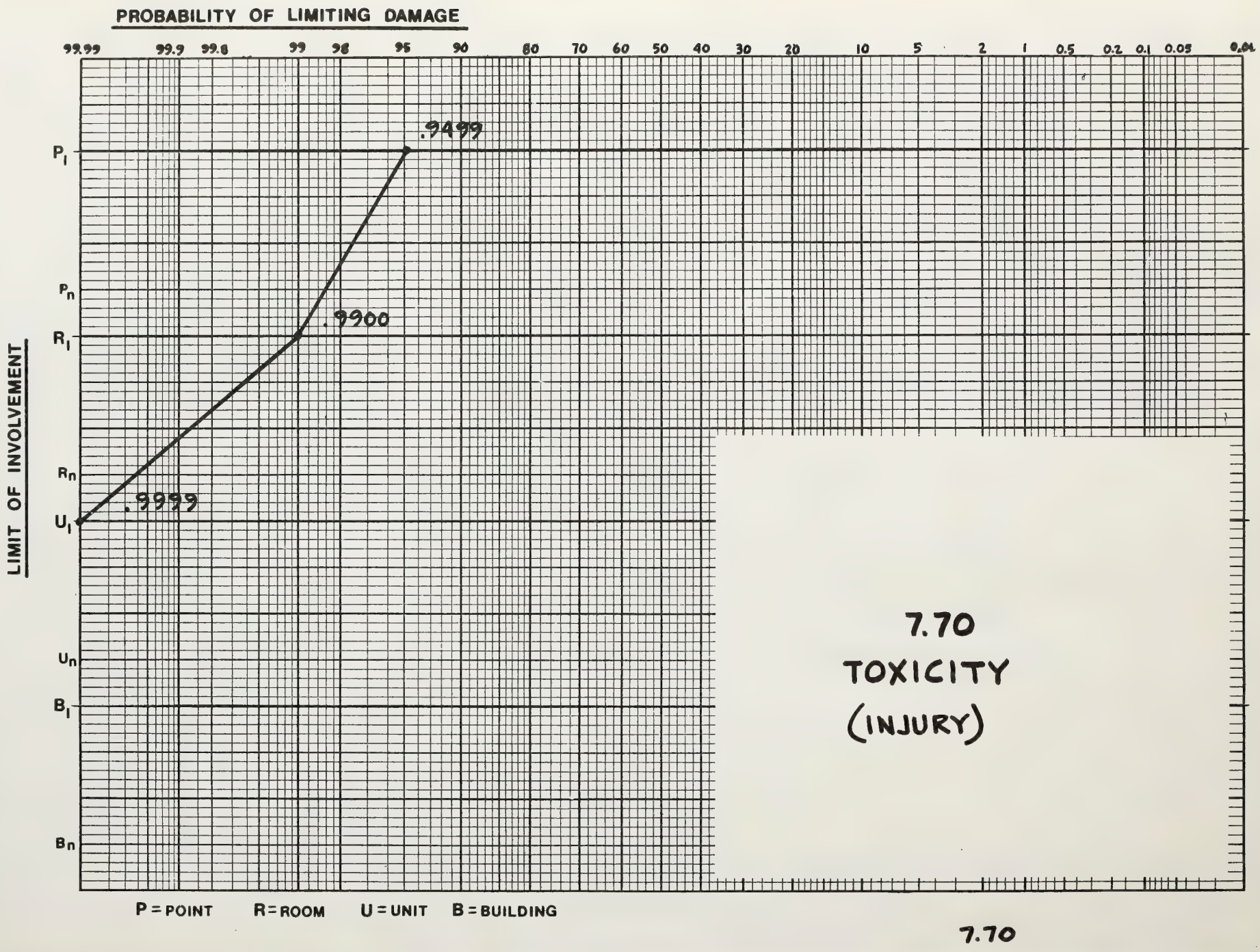
III-3.13 - Chart 7.61 - Visibility

Chart 7.61 represents visibility during the extinguishing process. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
LIMIT OF INVOLVEMENT
P_l
P_n
R_l
R_n
U_l
U_n
B_l
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.62
BREATHABILITY

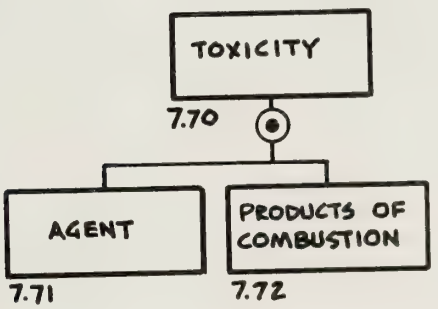
III-3.14 - Chart 7.62 - Breathability

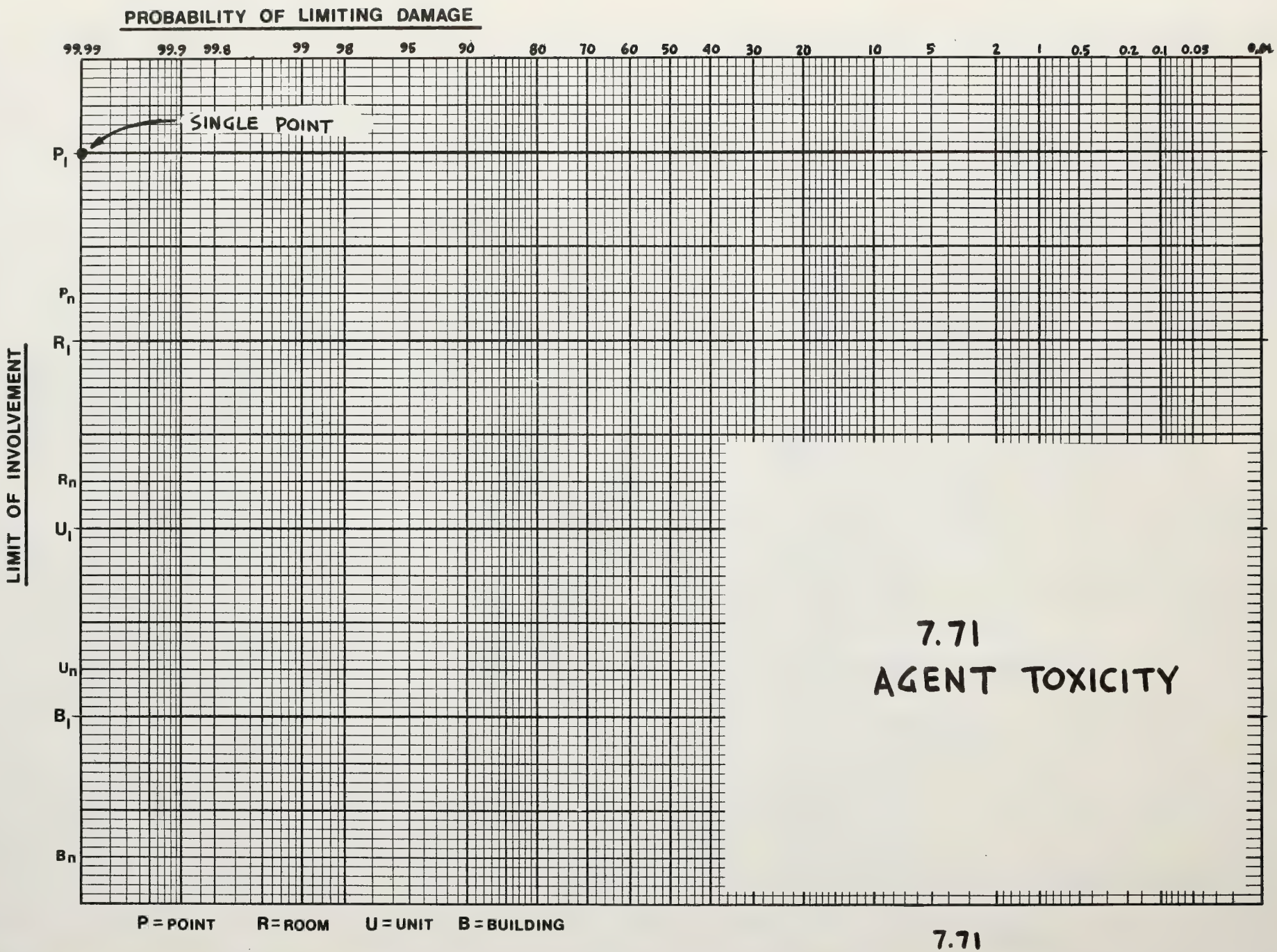
Chart 7.62 shows the impact of the extinguishing process on breathability. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9999
.9900
.9499
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.70
TOXICITY
(INJURY)

III-3.15 - Chart 7.70 - Toxicity

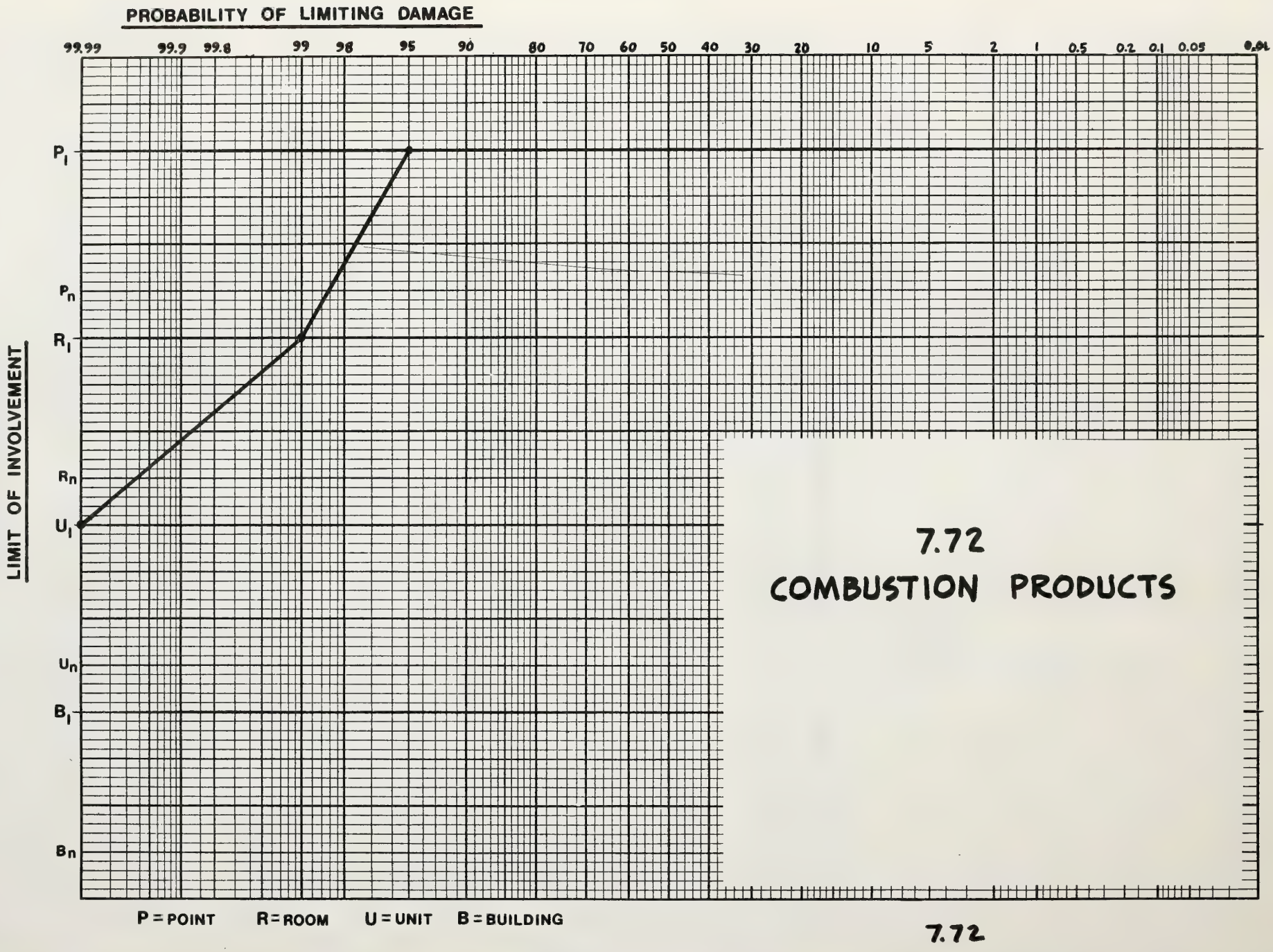
Chart 7.70 represents the toxicity increase occurring during the extinguishing process. It is the product of the agent toxicity and the increase in toxicity of the products of combustion combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
SINGLE POINT
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.71
AGENT TOXICITY

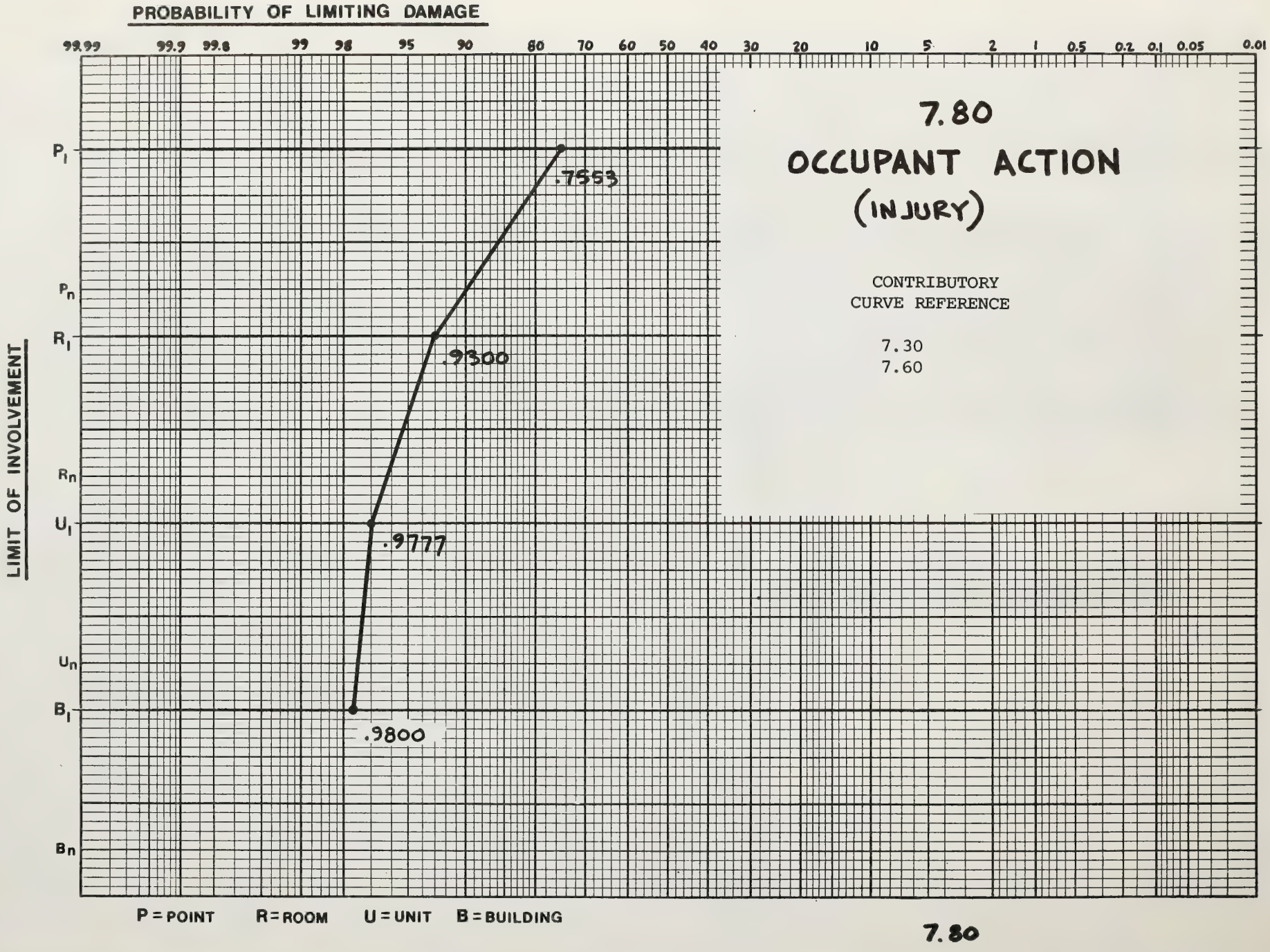
III-3.16 - Chart 7.71 - Agent Toxicity

Chart 7.71 is an expression of agent toxicity. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.72
COMBUSTION PRODUCTS

III-3.17 - Chart 7.72 - Combustion Products

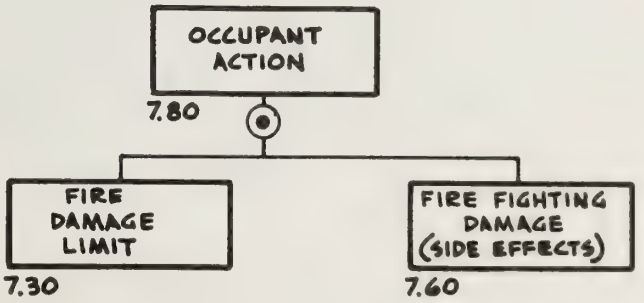
Chart 7.72 is an expression of the increased toxicity of the combustion products during the extinguishing process. The curve is based on judgment, considering fire records and research data.

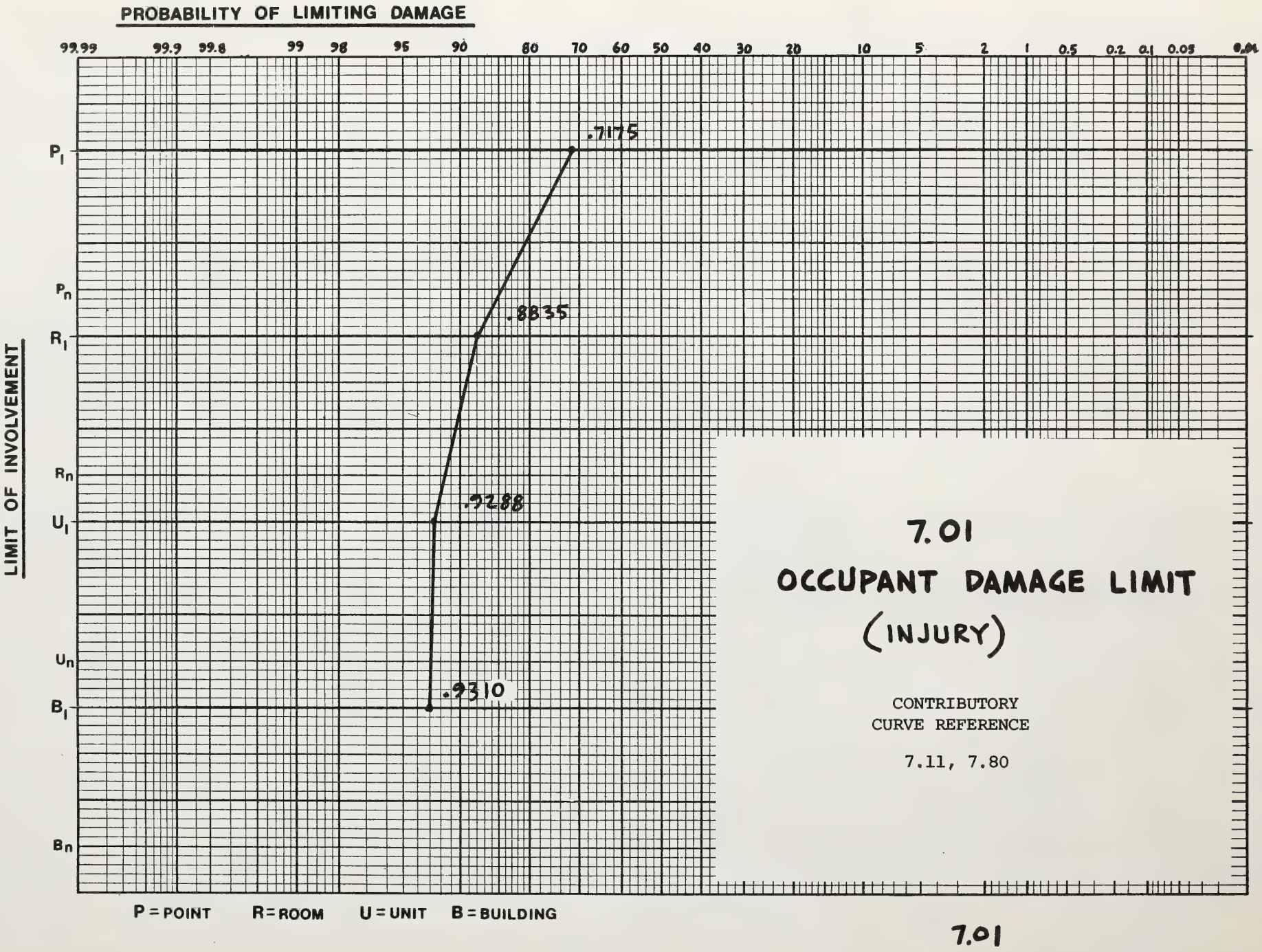

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.7553
.9300
.9777
.9800
7.80
OCCUPANT ACTION
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
7.30
7.60
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.80

III-3.18 - Chart 7.80 - Occupant Action

Chart 7.80 illustrates the effect of the occupant in limiting the human damage potential of residential fire. The curve was developed by combining the fire damage limit and the fire fighting damage limit through an "AND" gate.

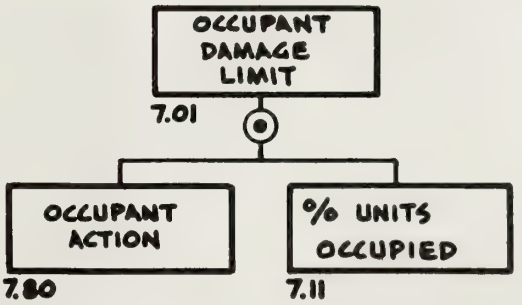
Chart 7.80 here

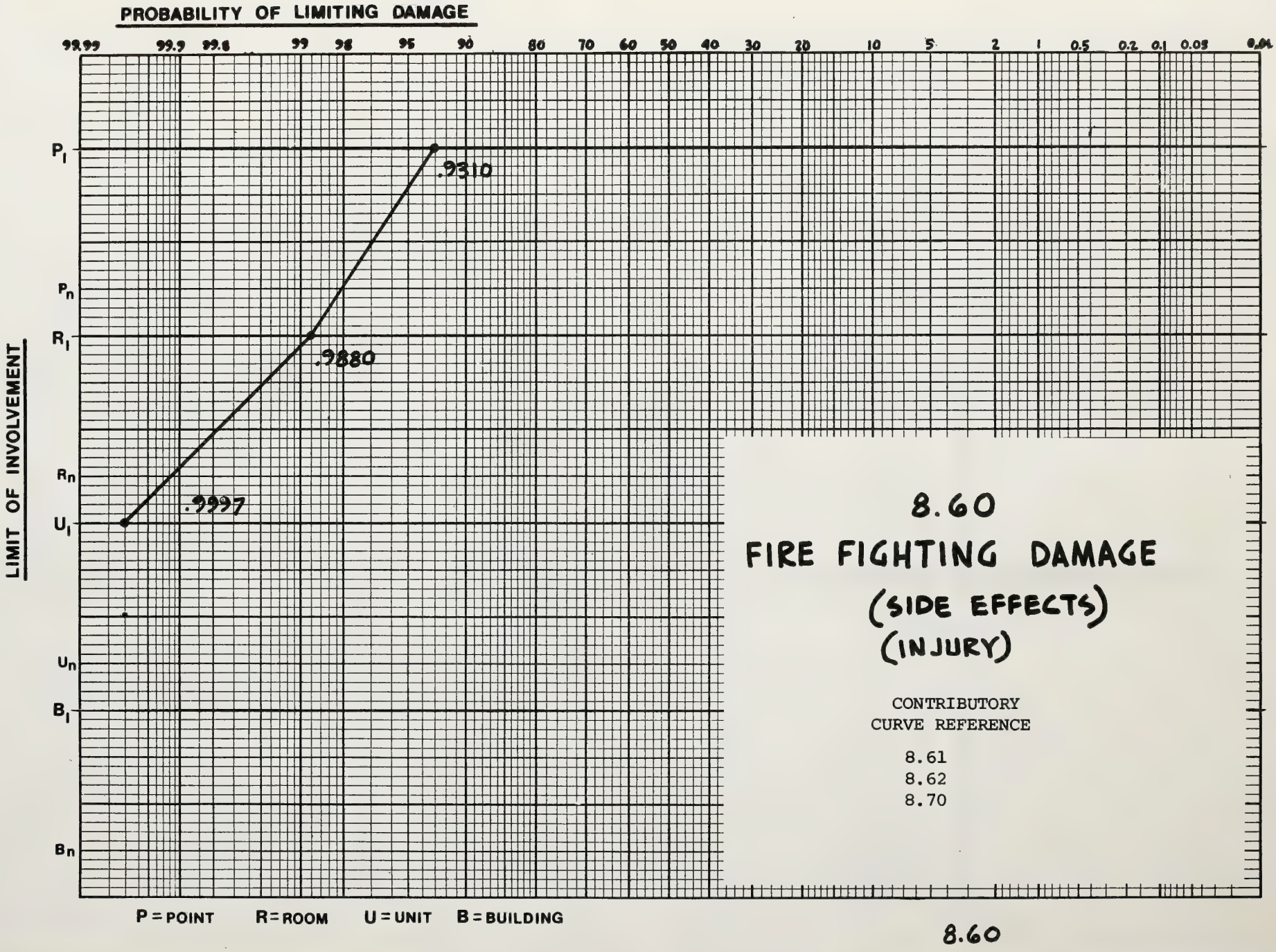



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.7175
.8835
.9288
.9310
P = POINT
R = ROOM
U = UNIT
B = BUILDING
7.01
OCCUPANT DAMAGE LIMIT
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
7.11, 7.80

III-3.19 - Chart 7.01 - Occupant Damage Limit

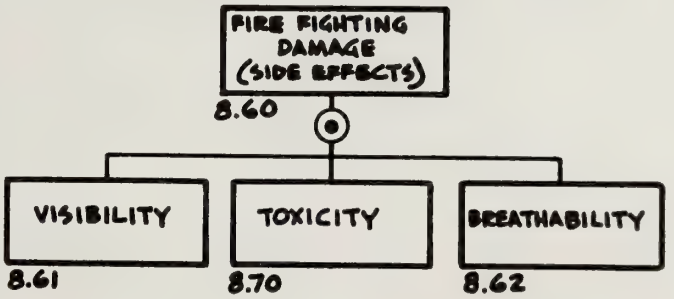
Chart 7.01 represents the impact on limiting human damage potential of residential fire caused by the actions of the occupant. The curve is the product of the occupant action and the percent units occupied combined through an "AND" gate.

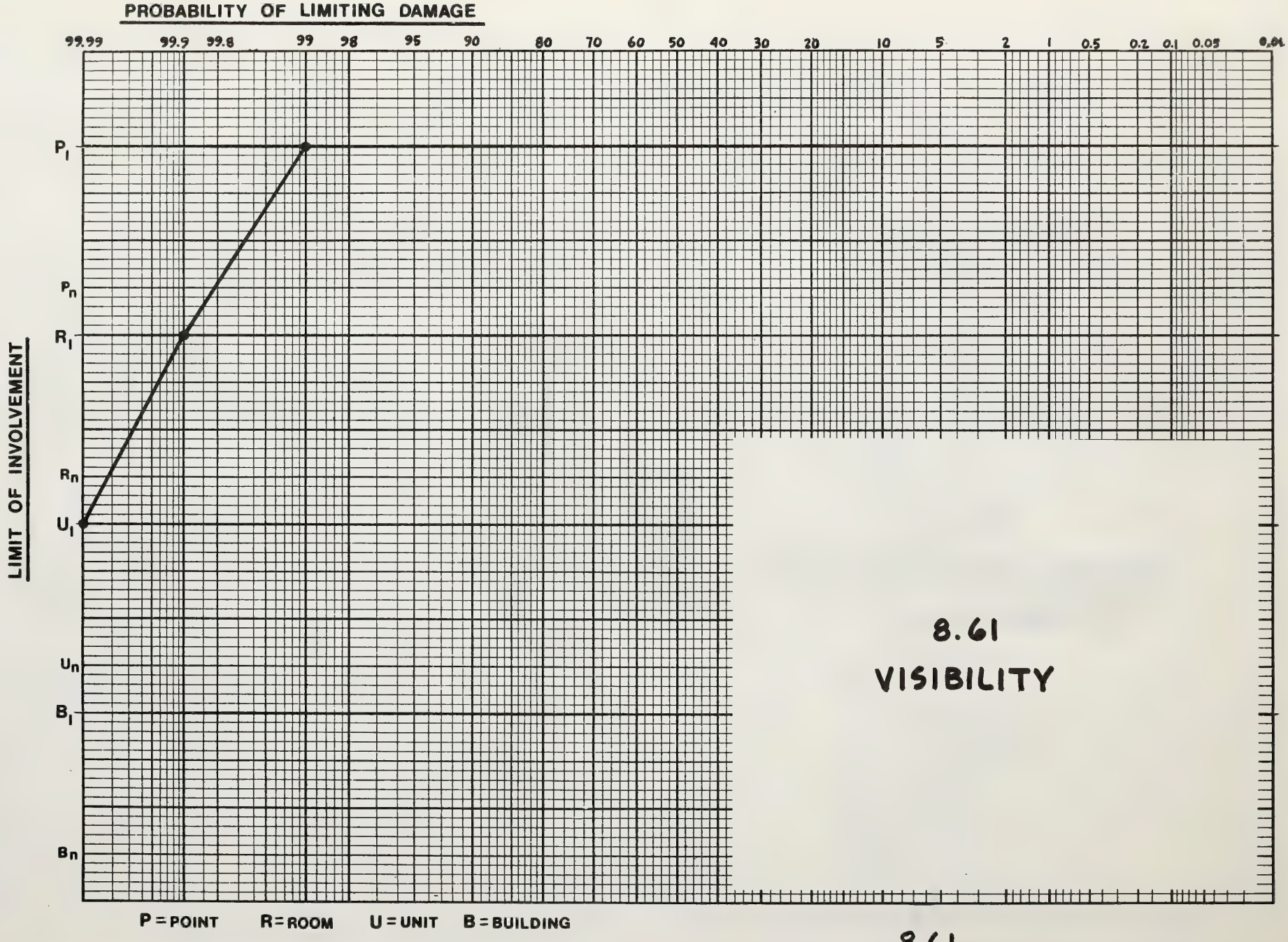



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9310
.9880
.9997
8.60
FIRE FIGHTING DAMAGE
(SIDE EFFECTS)
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
8.61
8.62
8.70
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.20 - Chart 8.60 - Fire Fighting Damage-Side Effects

Chart 8.60 represents the ability of manual fire fighting to limit human damage during the extinguishing process. This curve is a product of the visibility, breathability and toxicity occurring during extinguishment combined through an "AND" gate.

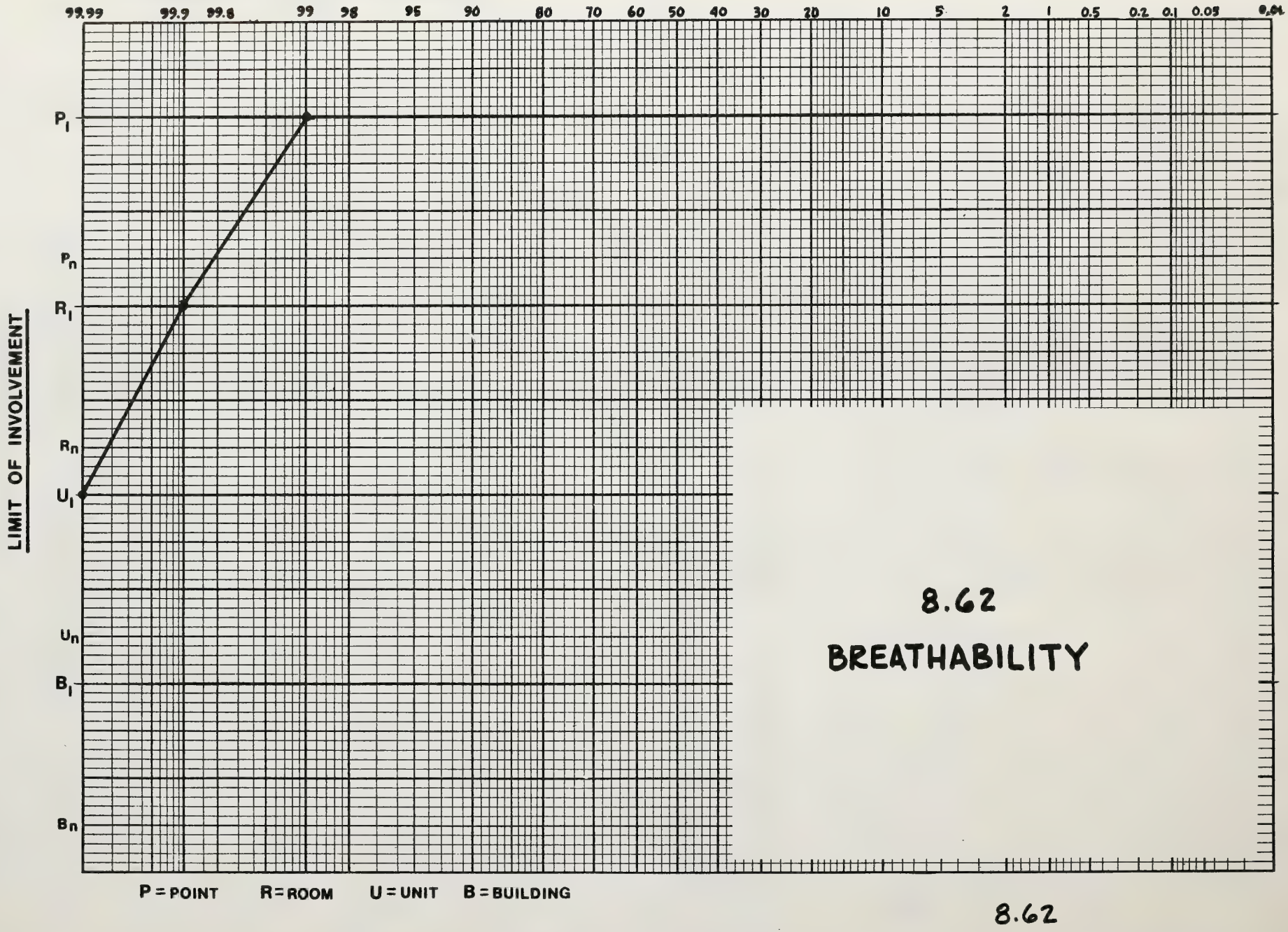




8.61
VISIBILITY

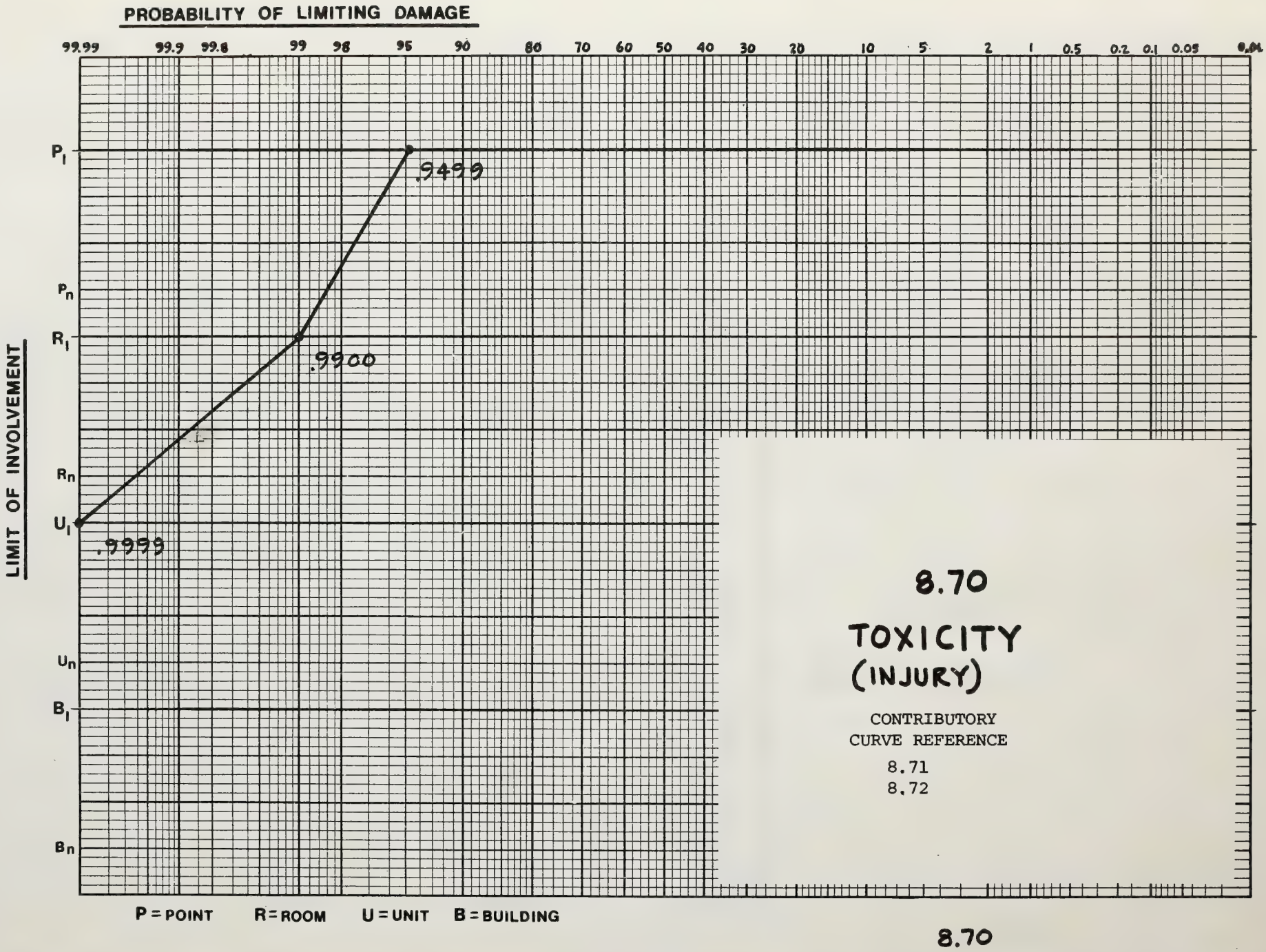
III-3.21 - Chart 8.61 - Visibility

Chart 8.61 shows the effects on visibility during the extinguishing process. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.62
BREATHABILITY

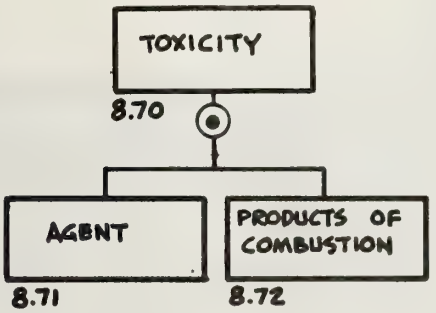
III-3.22 - Chart 8.62 - Breathability

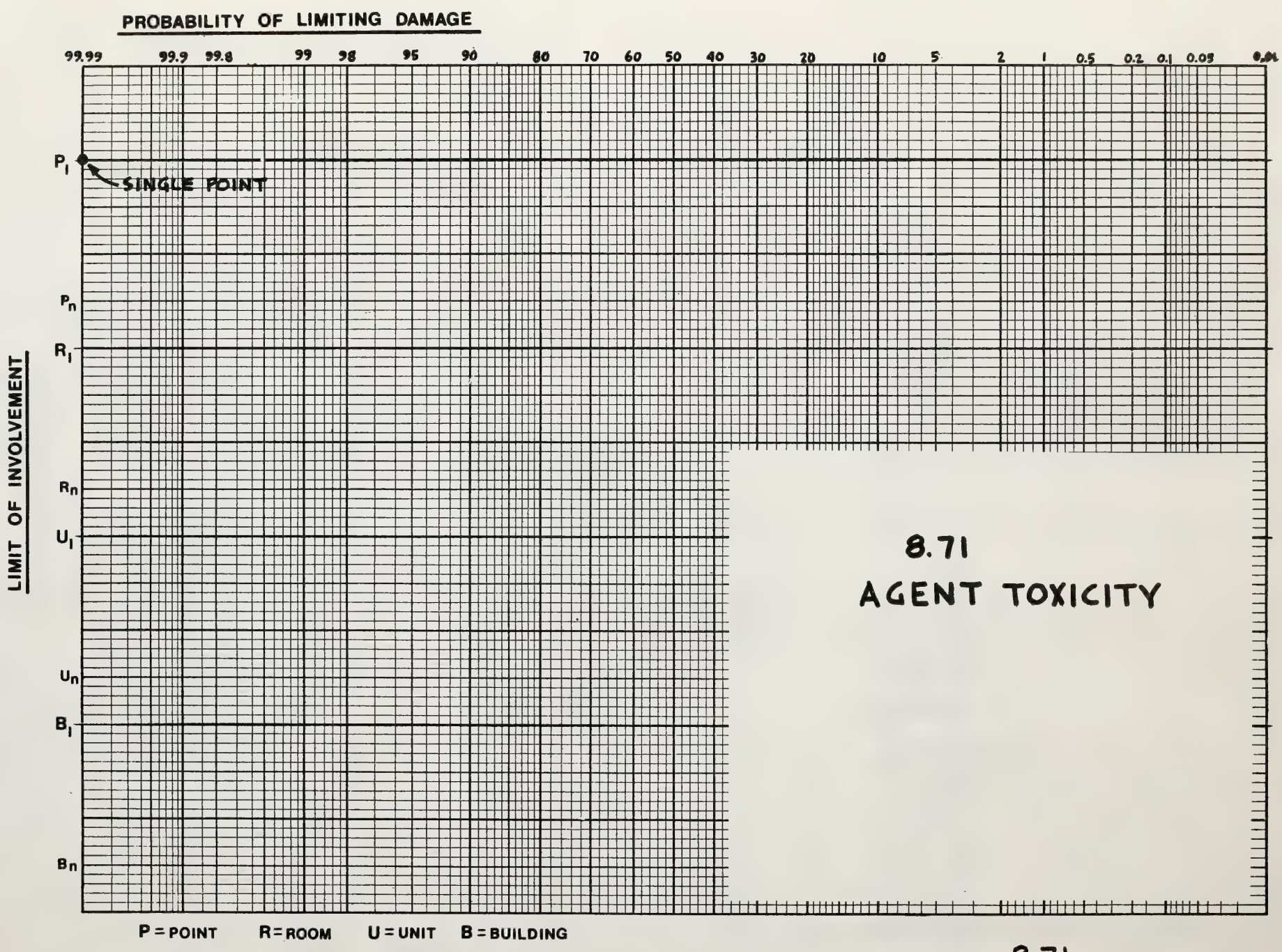
Chart 8.62 shows the impact of the extinguishing process on breathability. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.9499
.9900
.9999
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.70
TOXICITY
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
8.71
8.72

III-3.23 - Chart 8.70 - Toxicity

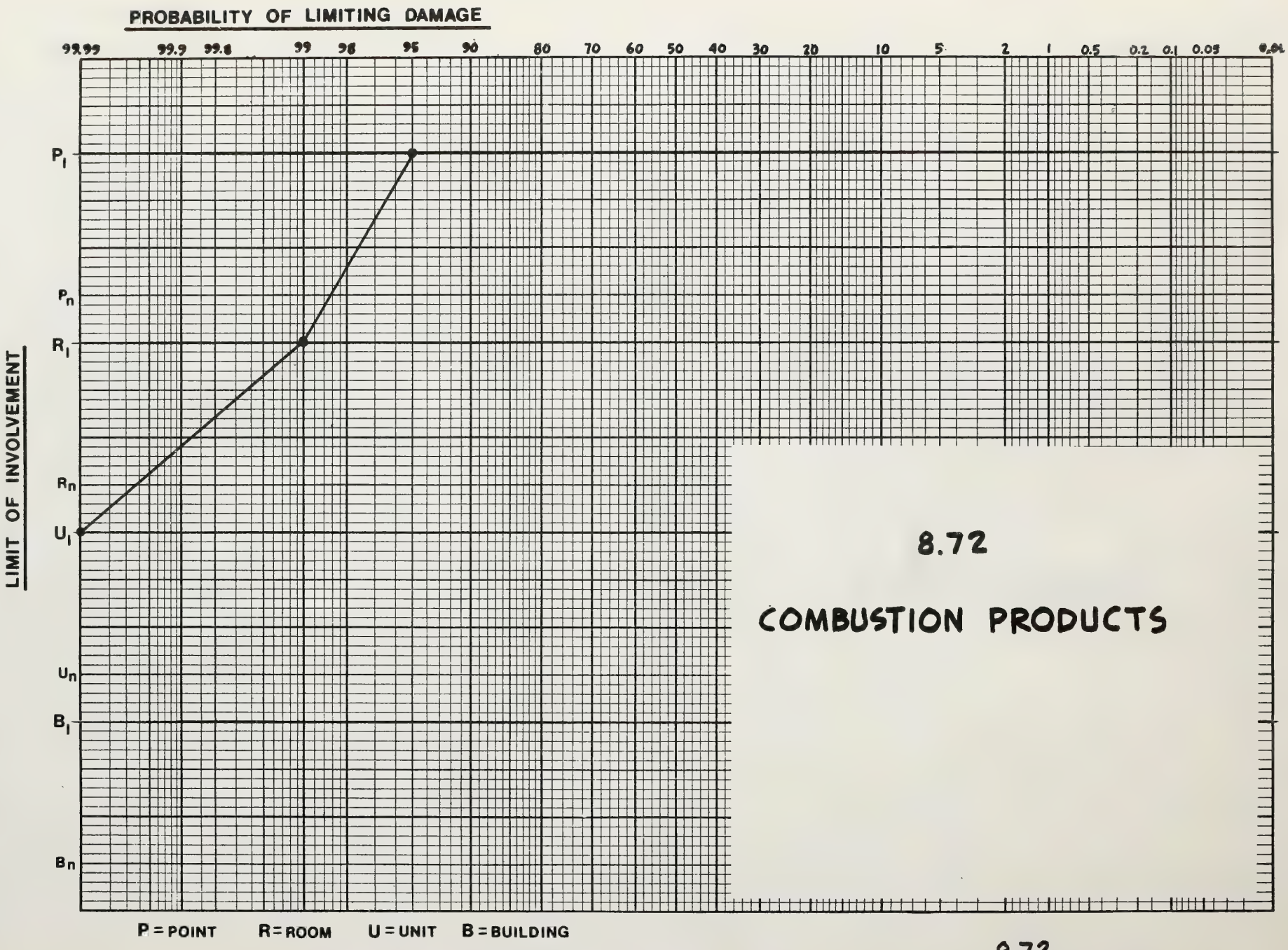
Chart 8.70 represents the toxicity increase occurring during the extinguishing process. It is the product of the agent toxicity and the increase in toxicity of the products of combustion combined through an "AND" gate.




PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
SINGLE POINT
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.71
AGENT TOXICITY

III-3.24 - Chart 8.71 - Agent Toxicity

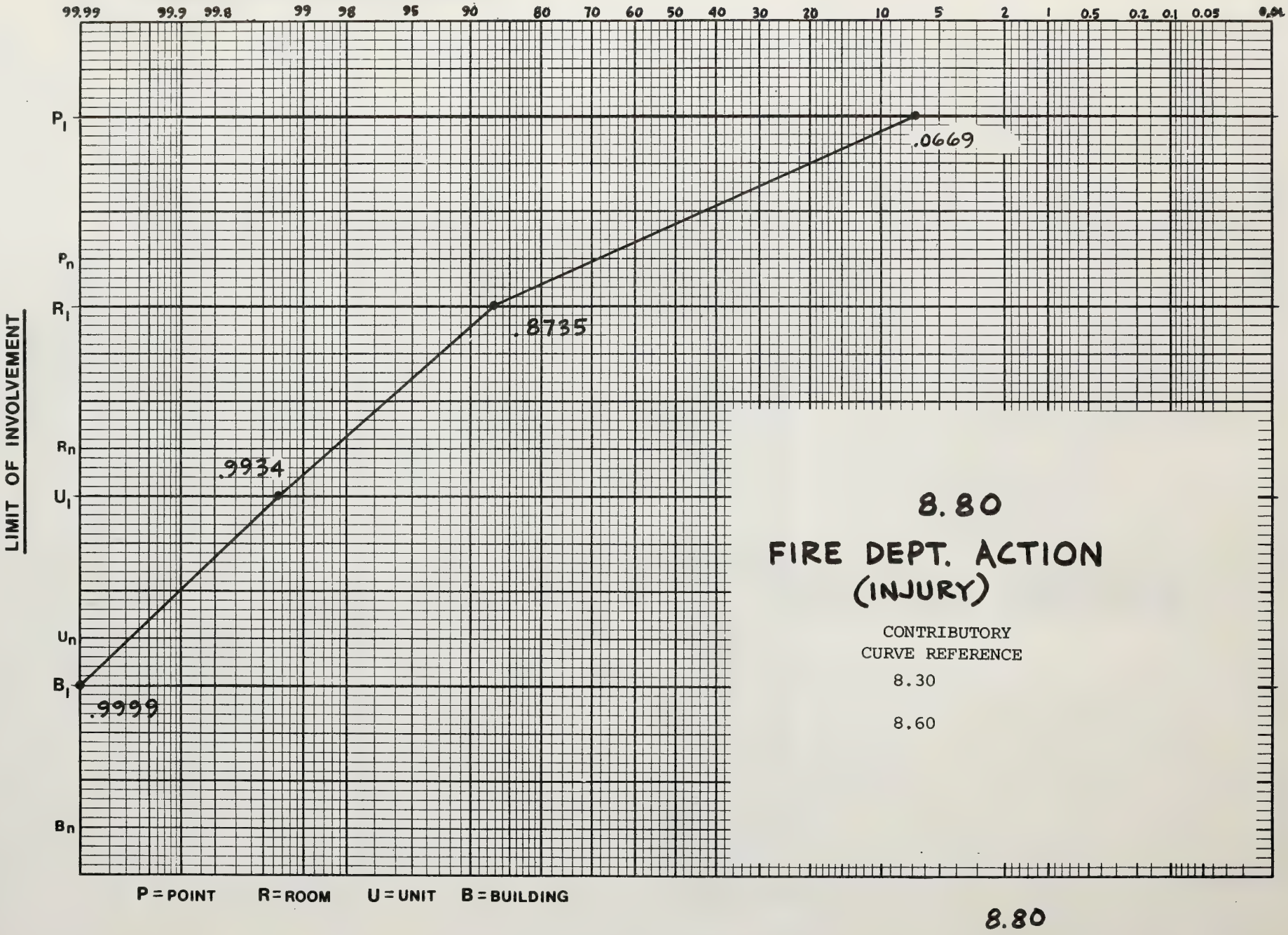
Chart 8.71 is an expression of agent toxicity. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
8.72
COMBUSTION PRODUCTS
P = POINT
R = ROOM
U = UNIT
B = BUILDING

8.72

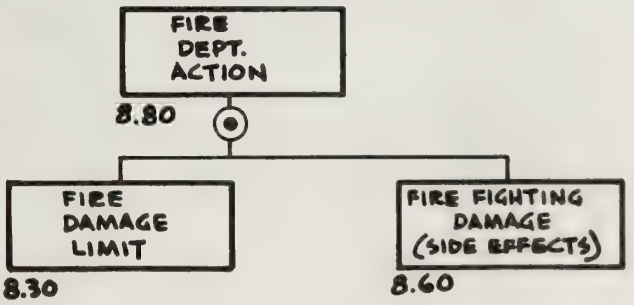
III-3.25 - Chart 8.72 - Combustion Products

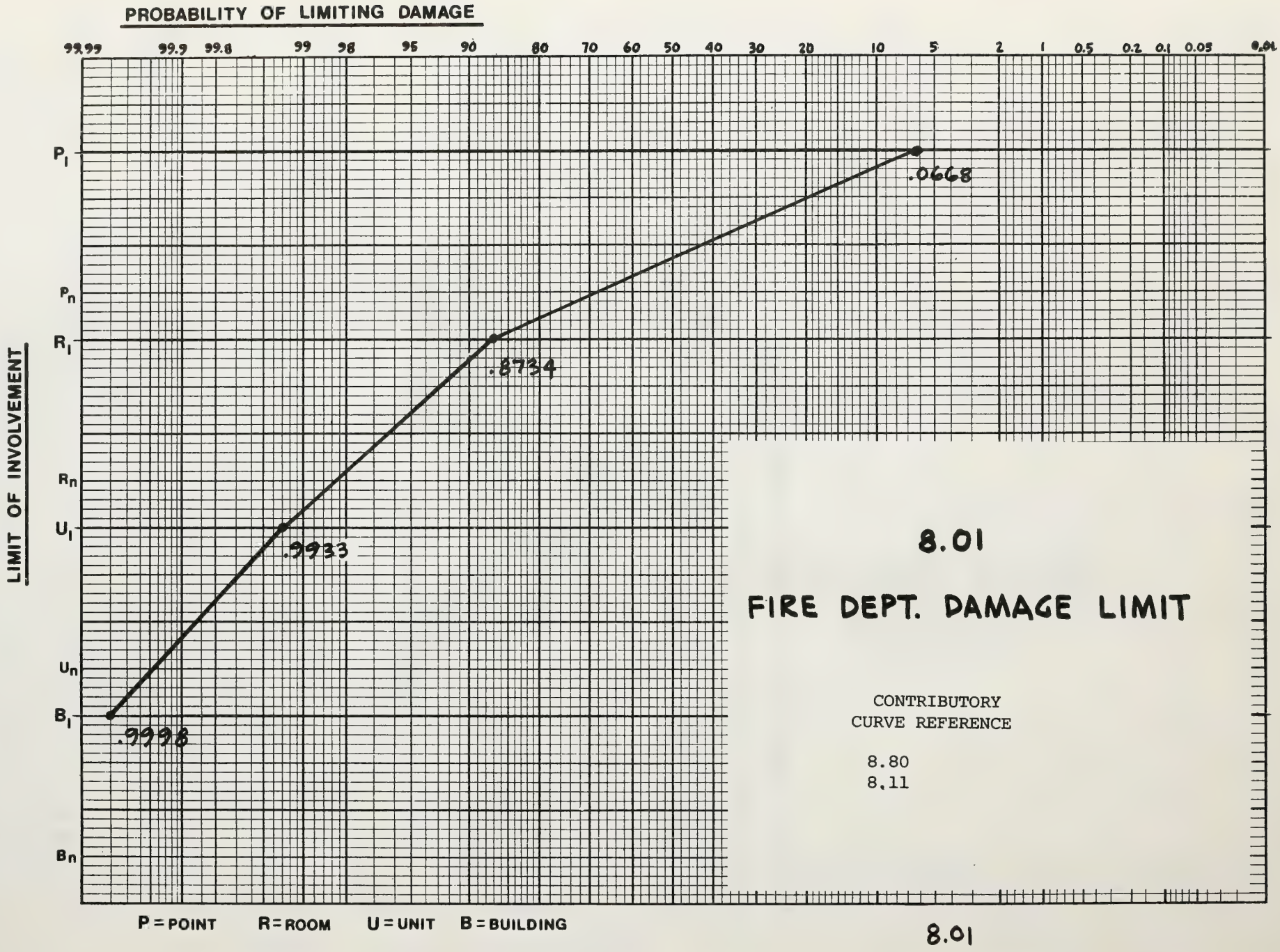
Chart 8.72 is an expression of the increased toxicity of the combustion products during the extinguishing process. The curve is based on judgment, considering fire records and research data.


PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
.0669
.8735
.9934
.9999
8.80
FIRE DEPT. ACTION
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
8.30
8.60
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.25 - Chart 8.80 - Fire Department Action

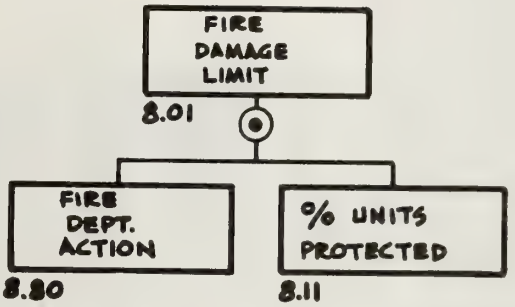
Chart 8.80 illustrates the effect of the fire department in limiting the human damage potential of residential fire. The curve was developed by combining the fire damage limit and the fire fighting damage limit through an "AND" gate.

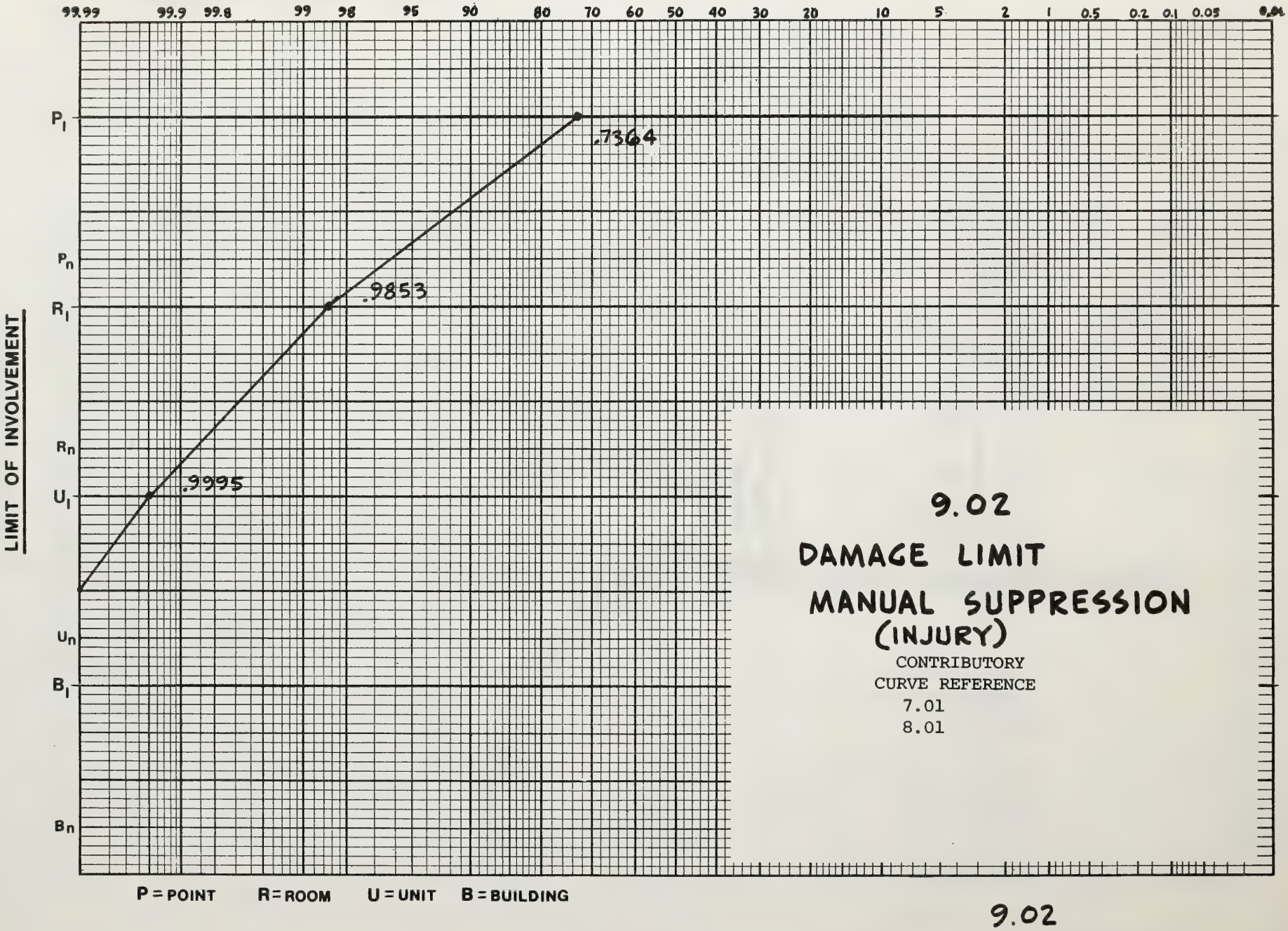



PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.0668
.8734
.9933
.9998
8.01
FIRE DEPT. DAMAGE LIMIT
CONTRIBUTORY
CURVE REFERENCE
8.80
8.11
P = POINT
R = ROOM
U = UNIT
B = BUILDING
8.01

III-3.27 - Chart 8.01 - Fire Department Damage Limit

Chart 8.01 represents the impact on limiting human damage potential of residential fire caused by the operations of the fire department. The curve is the product of the fire department action and the percent units protected combined through an "AND" gate.

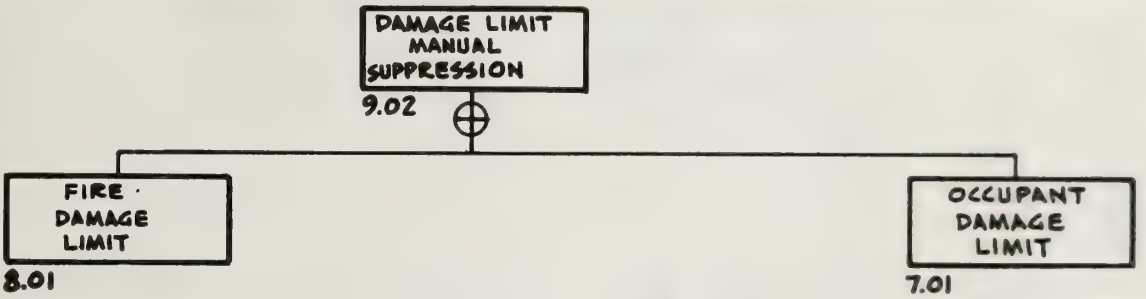


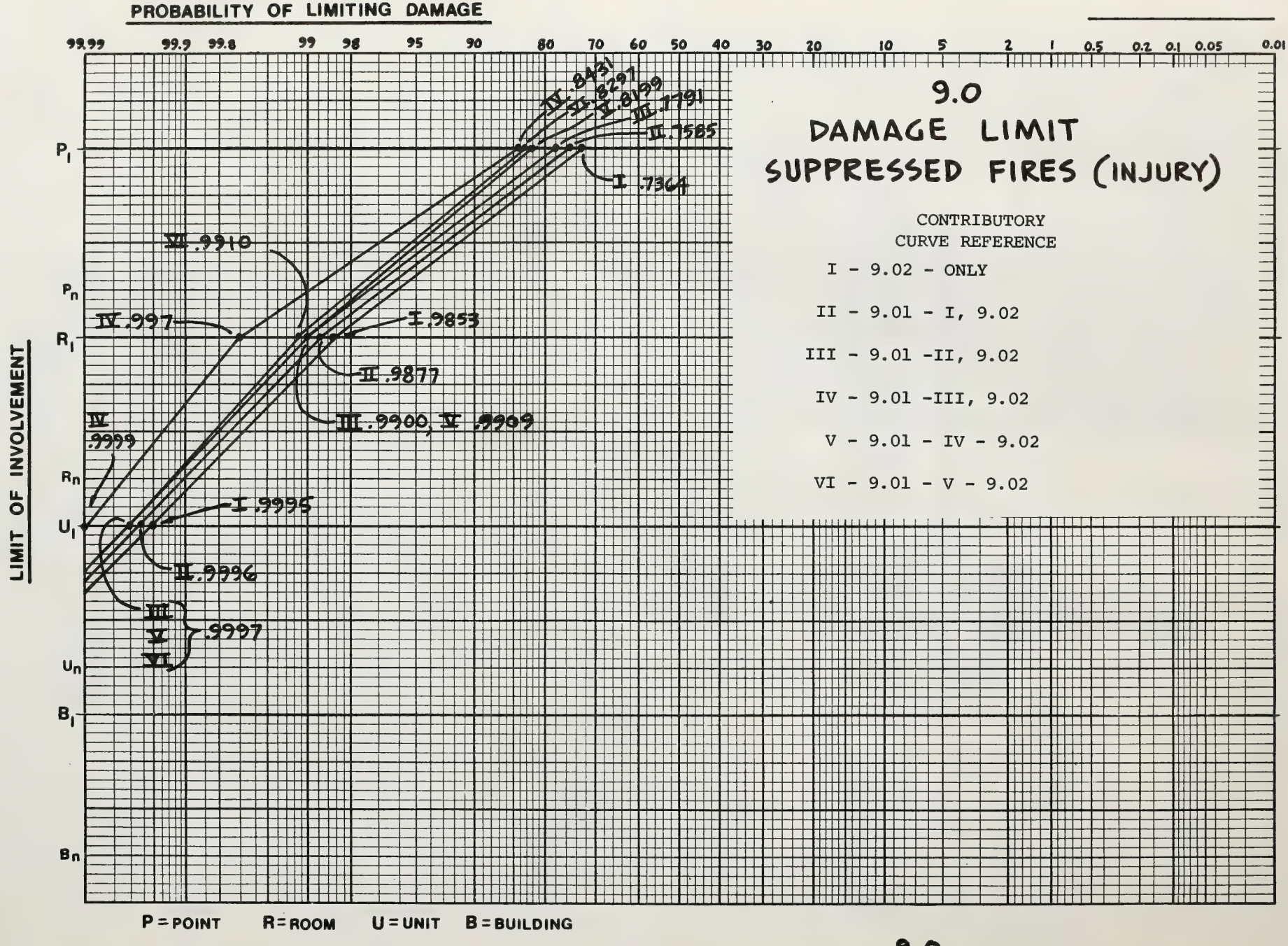

PROBABILITY OF LIMITING DAMAGE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
.7364
.9853
.9995
9.02
DAMAGE LIMIT
MANUAL SUPPRESSION
(INJURY)
CONTRIBUTORY
CURVE REFERENCE
7.01
8.01
P = POINT
R = ROOM
U = UNIT
B = BUILDING

9.02

III-3.28 - Chart 9.02 - Damage Limit Manual Suppression

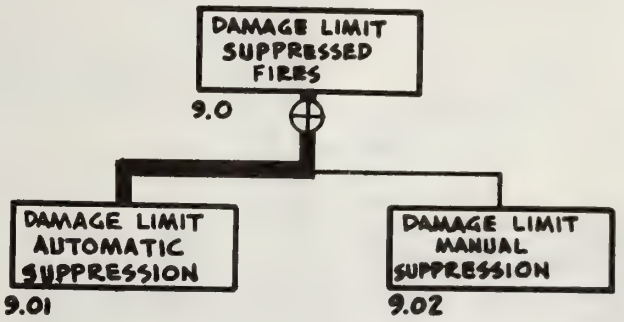
Chart 9.02 expresses the impact on limiting human damage potential of residential fire through manual suppression. It is the product of the fire department action and the occupant action combined through an "OR" gate.




PROBABILITY OF LIMITING DAMAGE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
P = POINT R = ROOM U = UNIT B = BUILDING
9.0
DAMAGE LIMIT
SUPPRESSED FIRES (INJURY)
CONTRIBUTORY
CURVE REFERENCE
I - 9.02 - ONLY
II - 9.01 - I, 9.02
III - 9.01 -II, 9.02
IV - 9.01 -III, 9.02
V - 9.01 - IV - 9.02
VI - 9.01 - V - 9.02
VI .9910
IV .997
I .9853
II .9877
III .9900, V .9909
IV .9999
I .9996
II .9996
III V VI .9997
I .7364
II .7585
III .7791
I .8199
II .8291
IV .8431

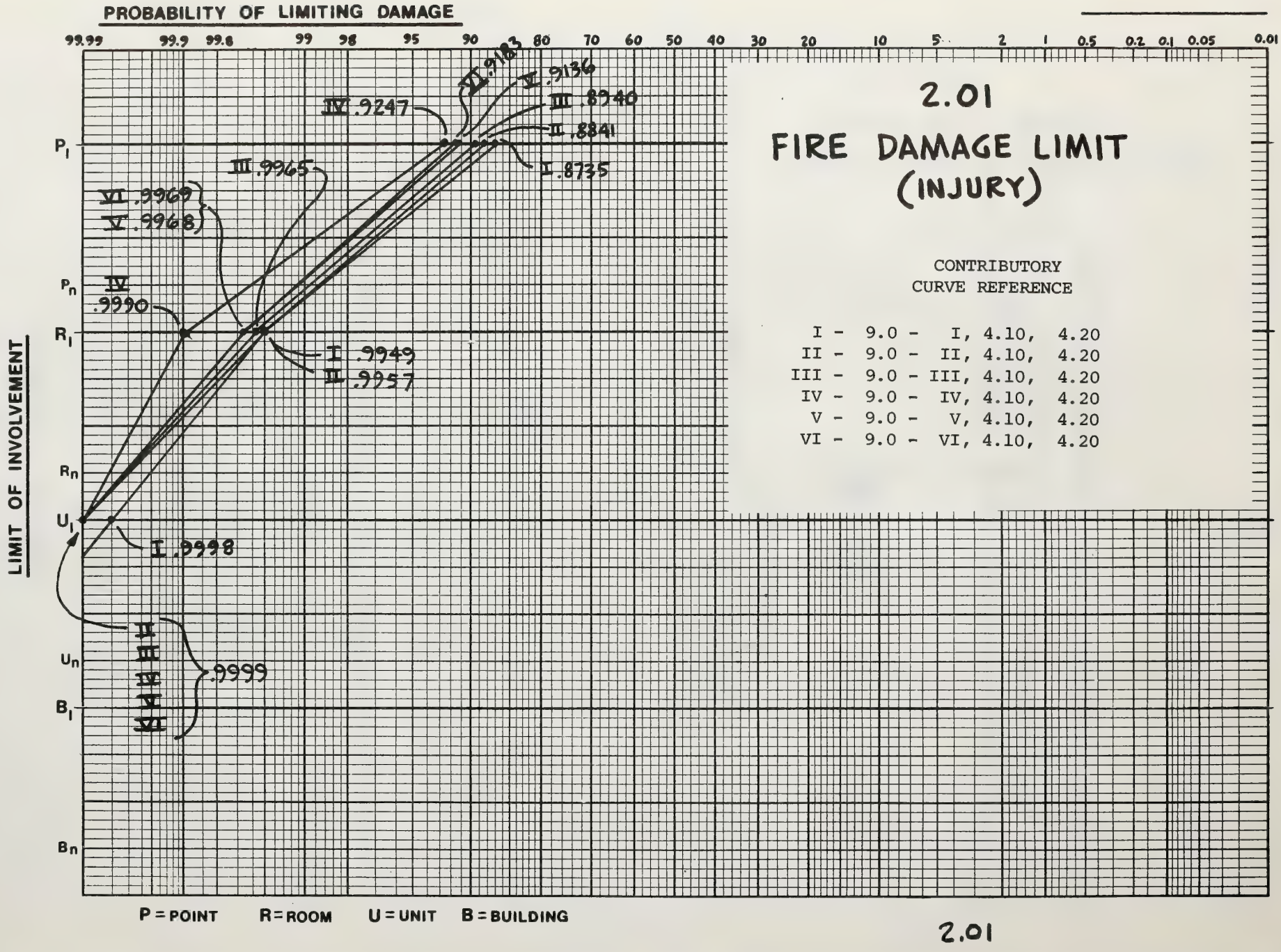
III-3.29 - Chart 9.0 - Damage Limit Suppressed Fires

III-3.29.1 Chart 9.0 illustrates the effect of suppression on the human damage potential of residential fire on a national basis. The curves are the sum of automatic suppression and manual suppression damage limits combined through an "OR" gate.



III-3.29.2 The curves shown on the chart represent

- Curve 1 - No system.
- Curve II - Level I system installed on a voluntary basis (1990).
- Curve III - Level I system required in all new residential units (1990).
- Curve IV - Level I system installed in all residential units (1990).
- Curve V - Level II system required in all new residential units (1990).
- Curve VI - Level III system required in all new residential units (1990).



2.01

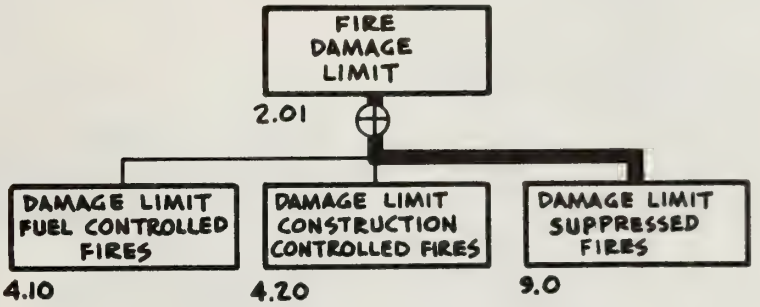
FIRE DAMAGE LIMIT (INJURY)

CONTRIBUTORY CURVE REFERENCE

I -	9.0 -	I, 4.10,	4.20
II -	9.0 -	II, 4.10,	4.20
III -	9.0 -	III, 4.10,	4.20
IV -	9.0 -	IV, 4.10,	4.20
V -	9.0 -	V, 4.10,	4.20
VI -	9.0 -	VI, 4.10,	4.20

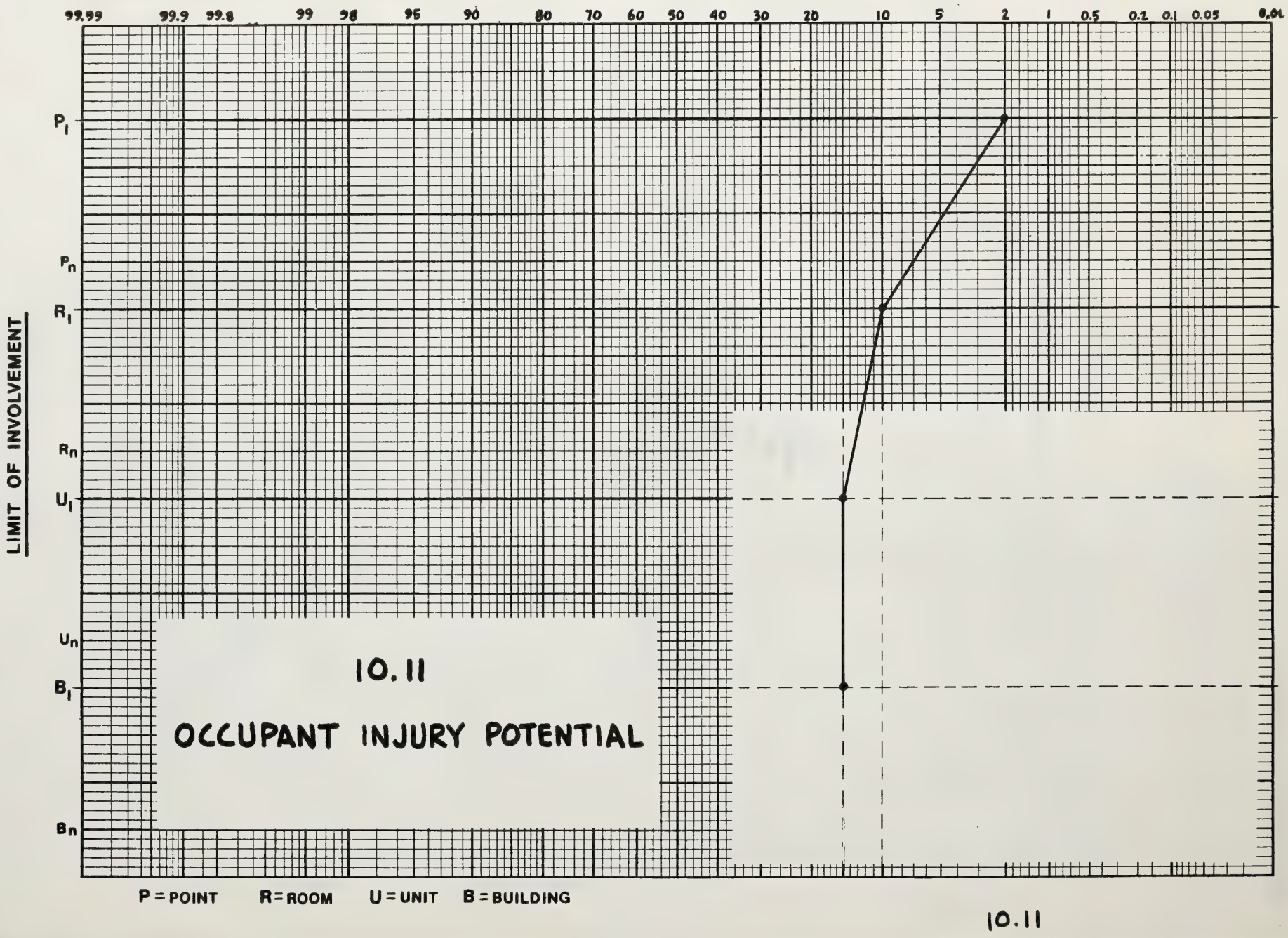
III-3.30 - Chart 2.01 - Fire Damage Limit

III-3.30.1 This chart is an expression of the probability of residential fire causing human damage. It is the sum of the human damage limit of fuel controlled fires, construction controlled fires and suppressed fires combined through an "OR" gate. It is an expression of fire severity.



III-3.30.2 The curves shown on the chart represent

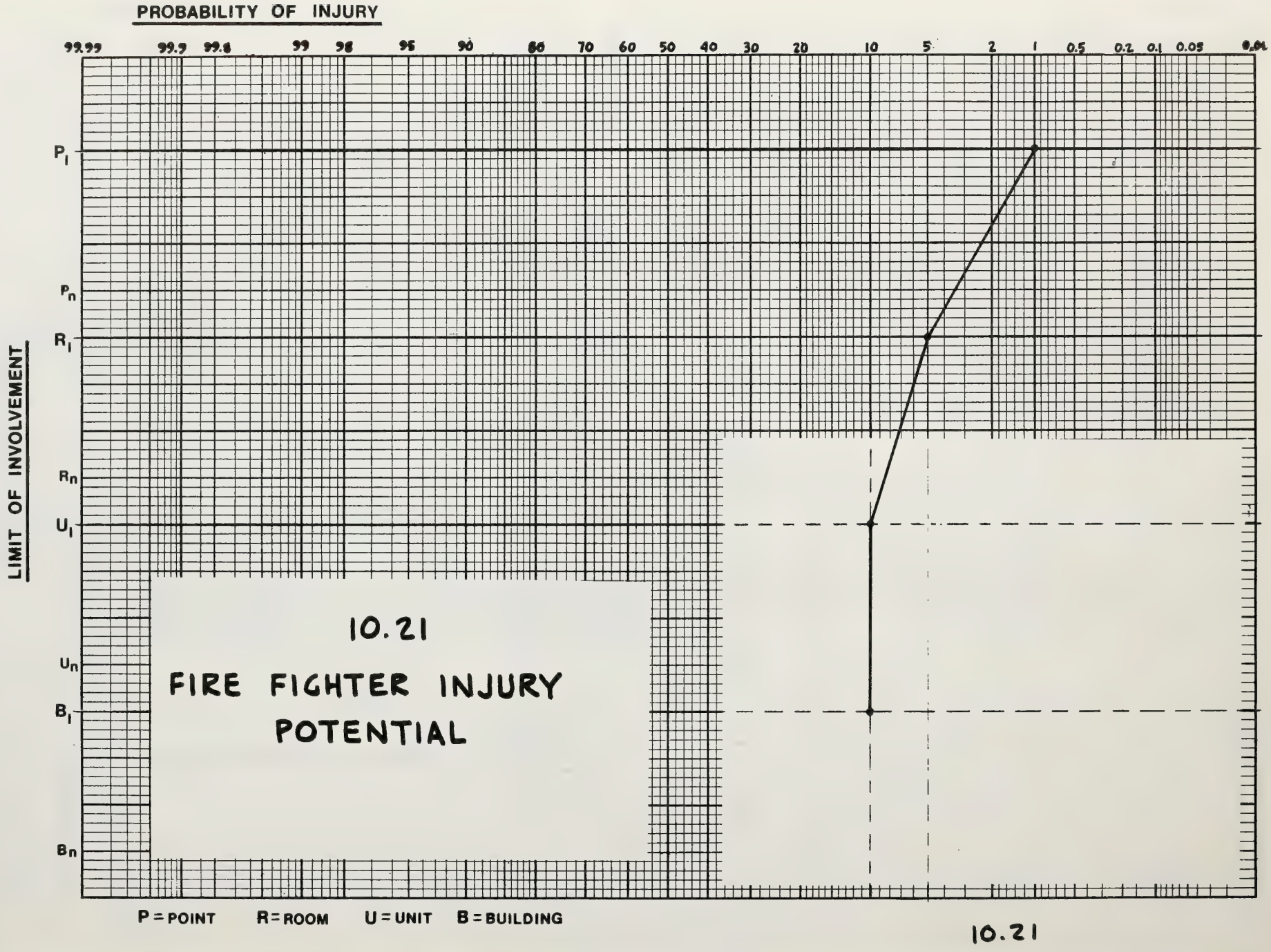
- Curve I - No system.
- Curve II - Level I system installed on a voluntary basis (1990).
- Curve III- Level I system required in all new residential units (1990).
- Curve IV - Level I system installed in all residential units (1990).
- Curve V - Level II system required in all new residential units (1990).
- Curve VI - Level III system required in all new residential units (1990).


PROBABILITY OF INJURY
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
10.11
OCCUPANT INJURY POTENTIAL
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.31 - Chart 10.11 - Occupant Injury Potential

III-3.31.1 Chart 10.11 expresses the probability of injury as it relates to fire severity. This curve is based on judgment.

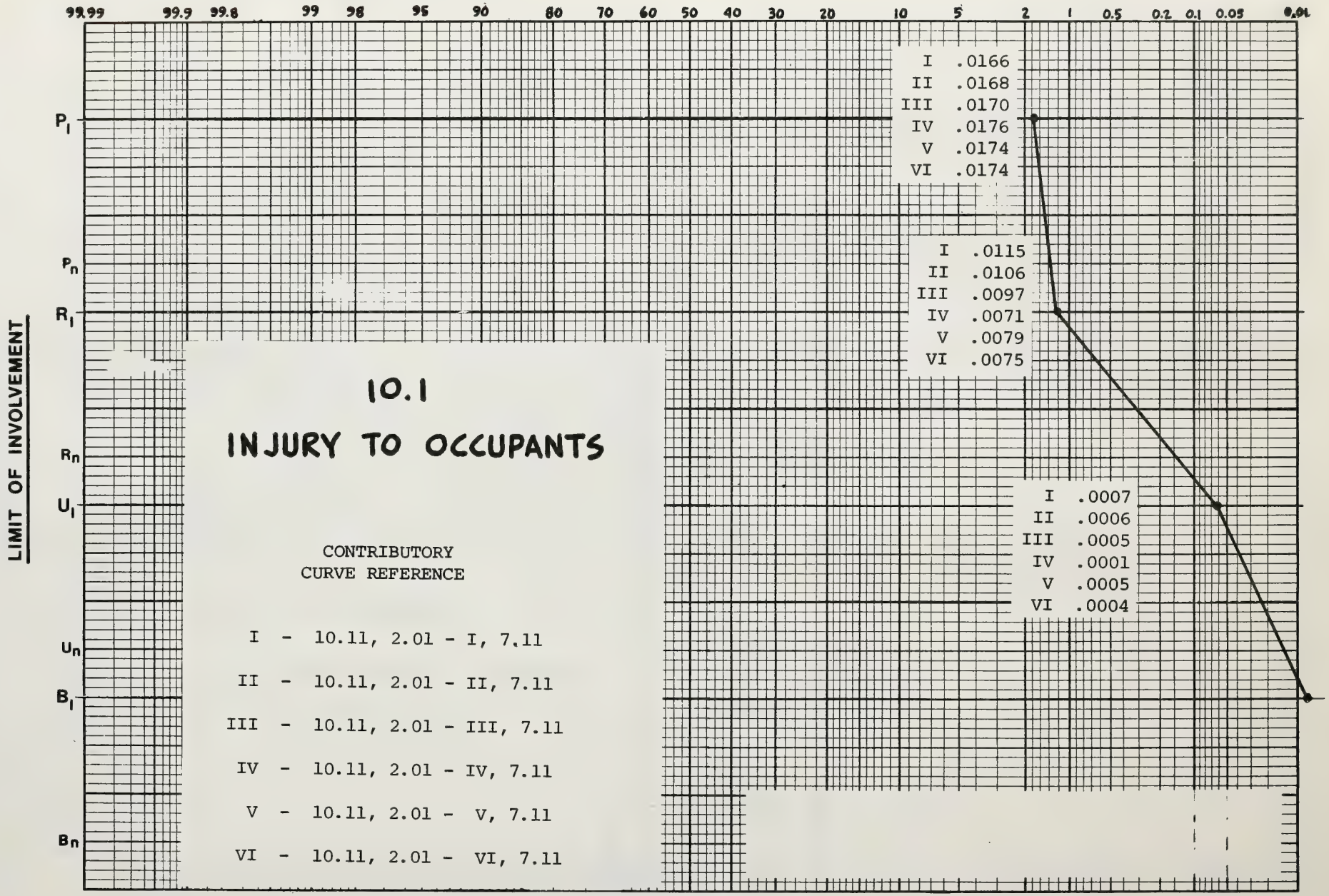
III-3.31.2 The curve is subject to such factors as population density, physical conditions of the occupants, psychological condition of the occupants, physiological conditions of the occupants, age of the occupants, mobility of the occupants, etc. Investigation of this item is beyond the scope of this project.


PROBABILITY OF INJURY
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
10.21
FIRE FIGHTER INJURY
POTENTIAL
P = POINT
R = ROOM
U = UNIT
B = BUILDING

III-3.32 - Chart 10.21 - Fire Fighter Injury Potential

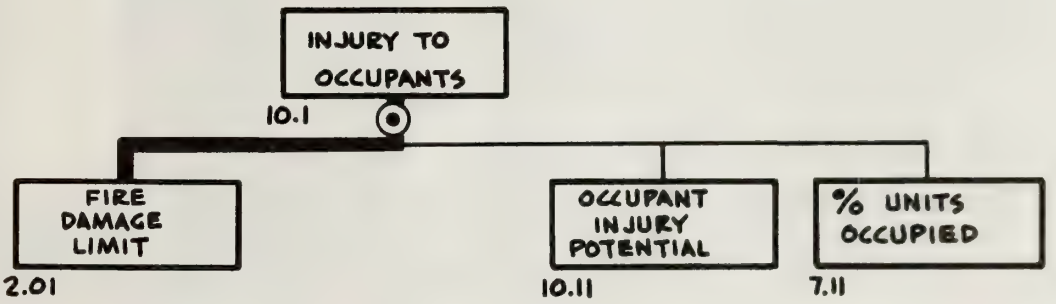
III-3.32.1 Chart 10.21 illustrates the susceptibility of fire fighters to injury as a function of fire severity. This curve is based on judgment.

III-3.32.2 The curve is subject to such factors as protective clothing, the type of equipment the fire department is using, fire ground communication, physical conditioning, weather, etc. Investigation of this item is beyond the scope of this project.


PROBABILITY OF INJURY PER FIRE
99.999 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I .0166
II .0168
III .0170
IV .0176
V .0174
VI .0174
I .0115
II .0106
III .0097
IV .0071
V .0079
VI .0075
I .0007
II .0006
III .0005
IV .0001
V .0005
VI .0004
10.1
INJURY TO OCCUPANTS
CONTRIBUTORY
CURVE REFERENCE
I - 10.11, 2.01 - I, 7.11
II - 10.11, 2.01 - II, 7.11
III - 10.11, 2.01 - III, 7.11
IV - 10.11, 2.01 - IV, 7.11
V - 10.11, 2.01 - V, 7.11
VI - 10.11, 2.01 - VI, 7.11
P = POINT R = ROOM U = UNIT B = BUILDING

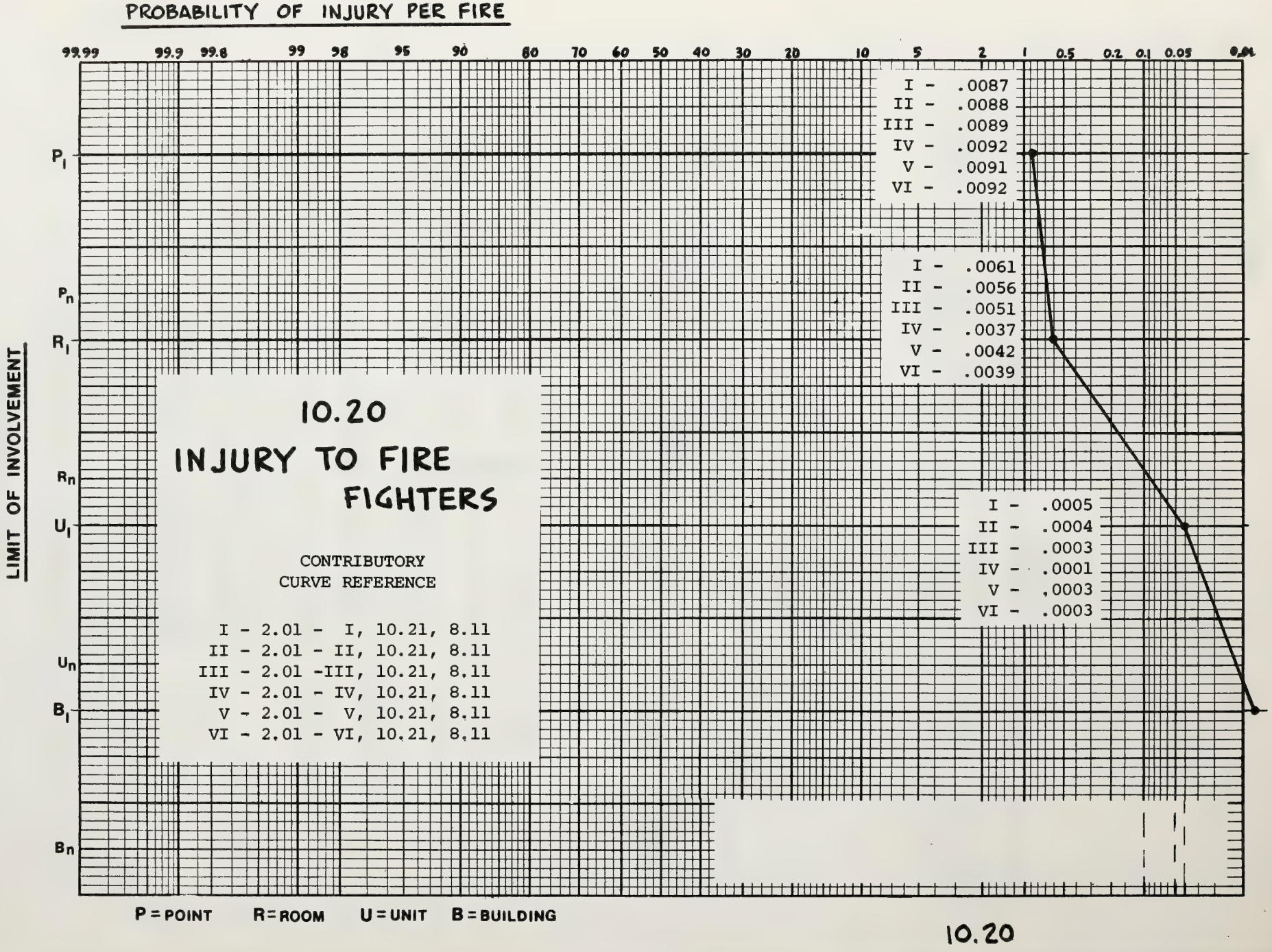
III-3.33 - Chart 10.1 - Injury to Occupants

III-3.33.1 Chart 10.1 expresses the probability of injury per fire. It is the product of the occupant injury potential, the percent of residential units which are occupied and the fire damage limit combined through an "AND" gate.



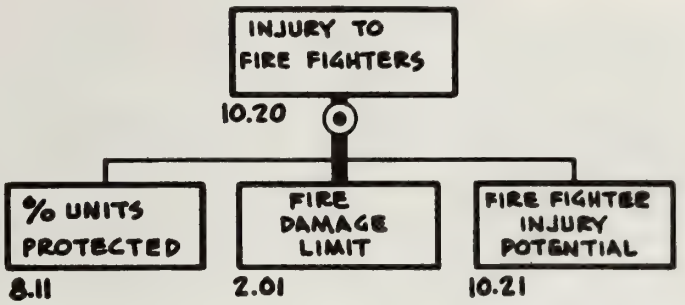
III-3.33.2 The curves shown on the chart represent

- o Curve I - No system.
- o Curve II - Level I system installed on a voluntary basis (1990).
- o Curve III - Level I system required in all new residential units (1990).
- o Curve IV - Level I system installed in all residential units (1990).
- o Curve V - Level II system required in all new residential units (1990).
- o Curve VI - Level III system required in all new residential units (1990).


PROBABILITY OF INJURY PER FIRE
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
LIMIT OF INVOLVEMENT
P1
Pn
R1
Rn
U1
Un
B1
Bn
I - .0087
II - .0088
III - .0089
IV - .0092
V - .0091
VI - .0092
I - .0061
II - .0056
III - .0051
IV - .0037
V - .0042
VI - .0039
I - .0005
II - .0004
III - .0003
IV - .0001
V - .0003
VI - .0003
10.20
INJURY TO FIRE FIGHTERS
CONTRIBUTORY CURVE REFERENCE
I - 2.01 - I, 10.21, 8.11
II - 2.01 - II, 10.21, 8.11
III - 2.01 -III, 10.21, 8.11
IV - 2.01 - IV, 10.21, 8.11
V - 2.01 - V, 10.21, 8.11
VI - 2.01 - VI, 10.21, 8.11
P = POINT R = ROOM U = UNIT B = BUILDING

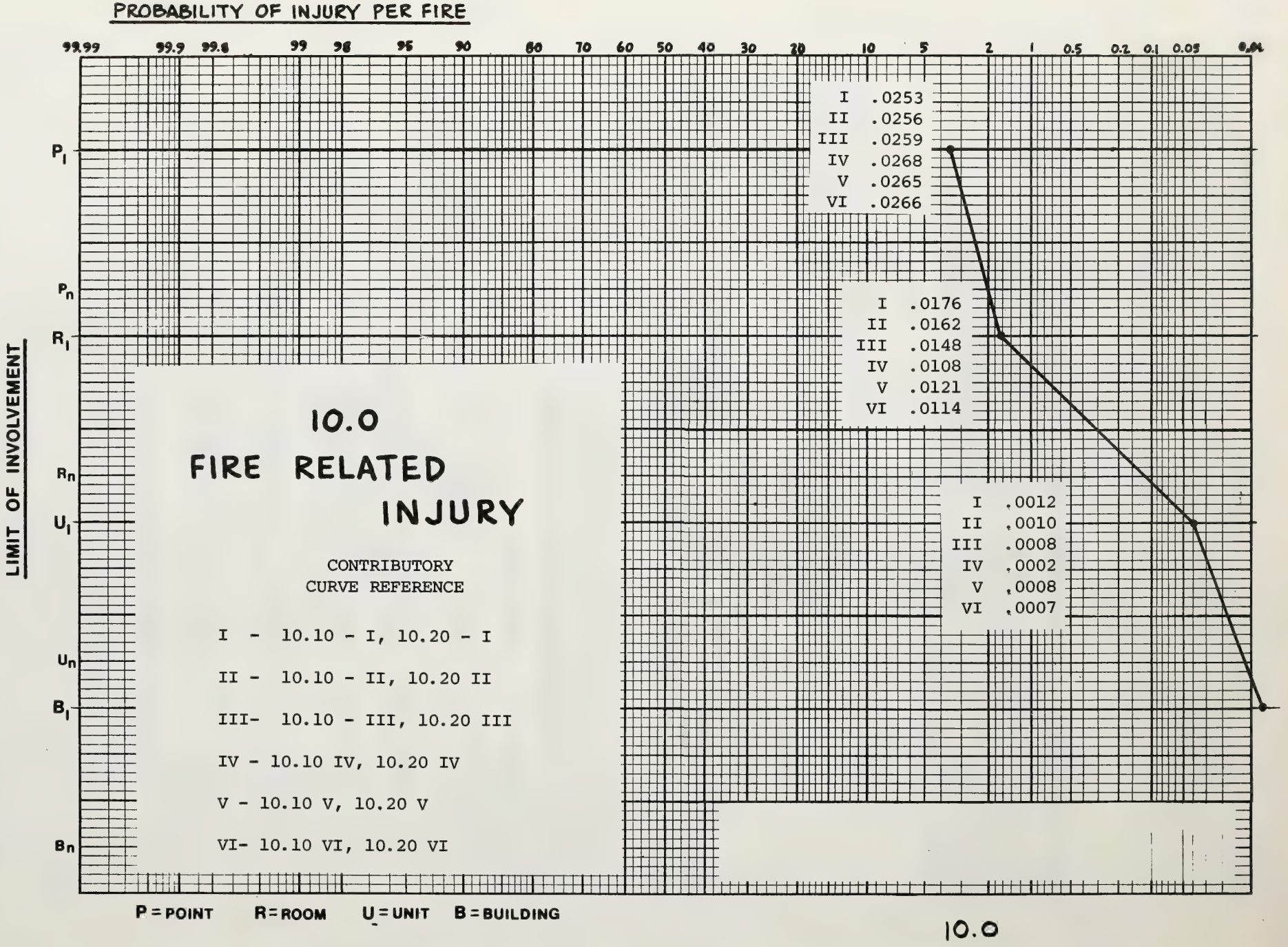
III-3.34 - Chart 10.20 - Injury to Fire Fighters

III-3.34.1 Chart 10.20 is also an expression of probability of injury per fire. The curve is the product of the fire damage limit, the fire fighter injury potential and the percent of the residential units which are protected combined through an "AND" gate.



III-3.34.2 The curves shown on the chart represent:

- Curve I - No system.
- Curve II - Level I system installed on a voluntary basis (1990).
- Curve III - Level I system required in all new residential units (1990).
- Curve IV - Level I system installed in all residential units (1990).
- Curve V - Level II system required in all new residential units (1990).
- Curve VI - Level III system required in all new residential units (1990).

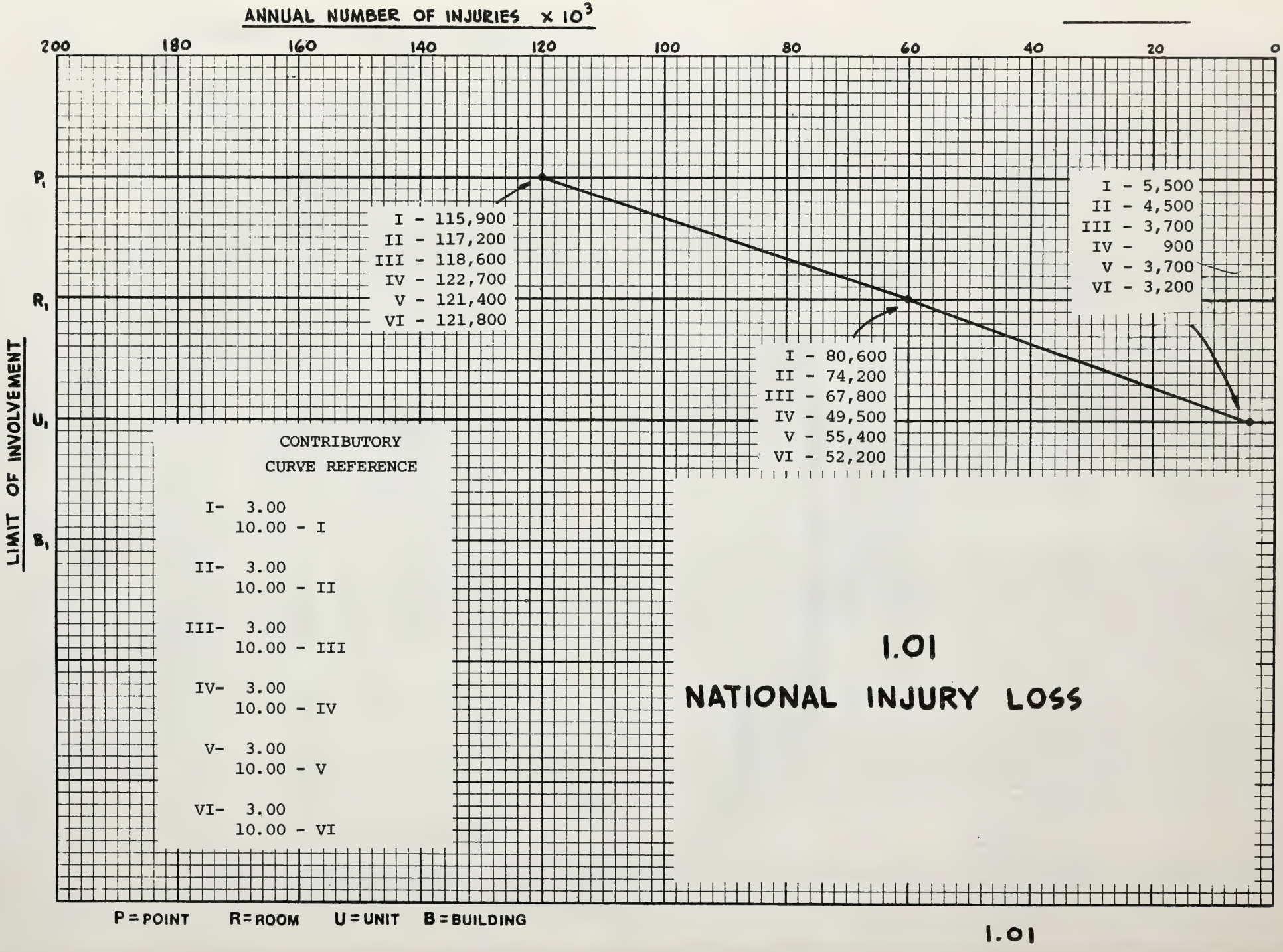

PROBABILITY OF INJURY PER FIRE
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
LIMIT OF INVOLVEMENT
P_I
P_n
R_I
R_n
U_I
U_n
B_I
B_n
I .0253
II .0256
III .0259
IV .0268
V .0265
VI .0266
I .0176
II .0162
III .0148
IV .0108
V .0121
VI .0114
I .0012
II .0010
III .0008
IV .0002
V .0008
VI .0007
10.0
FIRE RELATED
INJURY
CONTRIBUTORY
CURVE REFERENCE
I - 10.10 - I, 10.20 - I
II - 10.10 - II, 10.20 II
III- 10.10 - III, 10.20 III
IV - 10.10 IV, 10.20 IV
V - 10.10 V, 10.20 V
VI- 10.10 VI, 10.20 VI
P = POINT R = ROOM U = UNIT B = BUILDING

III-3.35 - Chart 10.0 - Fire Related Injury

III-3.35.1 Chart 10.0 represents the probability of injury per fire on a national basis. The curve was developed by combining the probability of injury to occupants and injury to fire fighters through an "OR" gate.

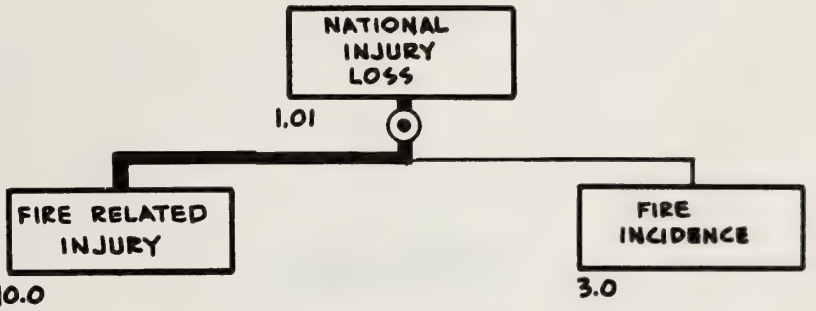
III-3.35.2 The curves shown on the chart represent:

- o Curve I - No system.
- o Curve II - Level I system installed on a voluntary basis (1990).
- o Curve III - Level I system required in all new residential units (1990).
- o Curve IV - Level I system installed in all residential units (1990).
- o Curve V - Level II system required in all new residential units (1990).
- o Curve VI - Level III system required in all new residential units (1990).


ANNUAL NUMBER OF INJURIES x 10^3
200
180
160
140
120
100
80
60
40
20
0
LIMIT OF INVOLVEMENT
P_1
R_1
U_1
B_1
I - 115,900
II - 117,200
III - 118,600
IV - 122,700
V - 121,400
VI - 121,800
I - 80,600
II - 74,200
III - 67,800
IV - 49,500
V - 55,400
VI - 52,200
I - 5,500
II - 4,500
III - 3,700
IV - 900
V - 3,700
VI - 3,200
CONTRIBUTORY
CURVE REFERENCE
I- 3.00
10.00 - I
II- 3.00
10.00 - II
III- 3.00
10.00 - III
IV- 3.00
10.00 - IV
V- 3.00
10.00 - V
VI- 3.00
10.00 - VI
1.01
NATIONAL INJURY LOSS
P = POINT R = ROOM U = UNIT B = BUILDING

III-3.36 - Chart 1.01 - National Injury Loss

III-3.36.1 Chart 1.01 is an expression of the number of fire caused injuries occurring on a national basis. The chart is the product of the probability of fire injury (severity) and fire incidence (frequency) combined through an "AND" gate. The actual dollar loss of injuries is calculated in Chapter 4-(4-6.2).



III-3.36.2 The curves shown on the chart represent

- o Curve I - No system.
- o Curve II - Level I system installed on a voluntary basis (1990).
- o Curve III - Level I system required in all new residential units (1990).
- o Curve IV - Level I system installed in all residential units (1990).
- o Curve V - Level II system required in all new residential units (1990).
- o Curve VI - Level III system required in all new residential units (1990).

APPENDIX IV

ASSIGNED LOSS CALCULATIONS

APPENDIX IV

Table of Contents

	Page
o Assigned Property Loss (4-6.1.2)	IV-1
o Assigned Injury Loss (4-6.2.2)	
1) Injury Distribution	IV-2
2) Assigned Loss	IV-3

ASSIGNED PROPERTY LOSS (4-6.1.2)

*Curve	Number of Fires	X	Assigned Loss/Fire	=	Assigned Loss
I	2,381,600		$ 25		$ 59,540,000
	2,093,100		300		627,930,000
	102,600		3,000		307,800,000
	2,700		50,000		135,000,000
TOTAL					$1,130,270,000
II	2,383,400		25		59,585,000
	2,104,100		300		631,230,000
	90,200		3,000		270,600,000
	2,300		50,000		115,000,000
TOTAL					$1,076,415,000
III	2,419,600		25		60,490,000
	2,080,300		300		624,090,000
	78,300		3,000		234,900,000
	1,800		50,000		90,000,000
TOTAL					$1,009,480,000
IV	2,475,500		25		61,887,500
	2,062,400		300		618,720,000
	41,700		3,000		125,100,000
	400		50,000		20,000,000
TOTAL					$ 825,707,500
V	2,454,900		25		61,372,500
	2,050,000		300		615,000,000
	73,300		3,000		219,900,000
	1,800		50,000		90,000,000
TOTAL					$ 986,272,500
VI	2,463,600		25		61,590,000
	2,042,200		300		612,660,000
	72,400		3,000		217,200,000
	1,800		50,000		90,000,000
TOTAL					$ 981,450,000

* From Chart 1.0

ASSIGNED INJURY LOSS (4-6.2.2)

1) INJURY DISTRIBUTION

*Curve	Severity	Point	Room	Unit/ Building	Total
I	Negligible	114,741	56,420	550	171,711
	Moderate	858	16,120	550	17,528
	Serious	290	4,030	2,200	6,520
	Fatal	11	4,030	2,200	6,241
TOTAL		115,900	80,600	5,500	202,000
II	Negligible	116,028	51,940	450	168,418
	Moderate	867	14,840	450	16,157
	Serious	293	3,710	1,800	5,803
	Fatal	12	3,710	1,800	5,522
TOTAL		117,200	74,200	4,500	195,900
III	Negligible	117,414	47,460	370	165,244
	Moderate	878	13,560	370	14,808
	Serious	296	3,390	1,480	5,166
	Fatal	12	3,390	1,480	4,882
TOTAL		118,600	67,800	3,700	190,100
IV	Negligible	121,473	34,650	90	156,213
	Moderate	908	9,900	90	10,898
	Serious	307	2,475	360	3,142
	Fatal	12	2,475	360	2,847
TOTAL		122,700	49,500	900	173,100
V	Negligible	120,186	38,780	370	159,336
	Moderate	898	11,080	370	12,348
	Serious	304	2,770	1,480	4,554
	Fatal	12	2,770	1,480	4,262
TOTAL		121,400	55,400	3,700	180,500
VI	Negligible	120,582	36,540	320	157,442
	Moderate	901	10,440	320	11,661
	Serious	305	2,610	1,280	4,195
	Fatal	12	2,610	1,280	3,902
TOTAL		121,800	52,200	3,200	177,200

*From Chart 1.01

2) ASSIGNED LOSS

*Curve	Number of Injuries	X	Assigned Loss/Injury	=	Assigned Loss
I	171,711	$	25	= $	4,292,775
	17,528		2,000	=	35,056,000
	6,520		100,000	=	652,000,000
	6,241		1,000,000	=	6,241,000,000
TOTAL				$	6,932,348,775
II	168,418	$	25	= $	4,210,450
	16,157		2,000	=	32,314,000
	5,803		100,000	=	580,300,000
	5,522		1,000,000	=	5,522,000,000
TOTAL				$	6,138,824,450
III	165,244	$	25	= $	4,131,100
	14,808		2,000	=	29,616,000
	5,166		100,000	=	516,600,000
	4,882		1,000,000	=	4,882,000,000
TOTAL				$	5,432,347,100
IV	156,213	$	25	= $	3,905,325
	10,898		2,000	=	21,796,000
	3,142		100,000	=	314,200,000
	2,847		1,000,000	=	2,847,000,000
TOTAL				$	3,186,901,325
V	159,336	$	25	= $	3,983,400
	12,348		2,000	=	24,696,000
	4,554		100,000	=	455,400,000
	4,262		1,000,000	=	4,262,000,000
TOTAL				$	4,746,079,400
VI	157,442	$	25	= $	3,936,050
	11,661		2,000	=	23,322,000
	4,195		100,000	=	419,500,000
	3,902		1,000,000	=	3,902,000,000
TOTAL				$	4,348,758,050

*From Chart 1.01

APPENDIX V

AUTOMATIC DWELLING SPRINKLER SYSTEM

DESIGN STANDARD

"Standard For Installation of Dwelling Sprinkler Systems"

"Note -- This Standard was developed using the 1975 Edition of NFPA 13D, 'Standard for Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes,' copyright 1975 by the National Fire Protection Association, Boston, MA 02210. This copyright material is printed in italics to differentiate it from the rest of the material."

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"Standard for Installation of Dwelling Sprinkler Systems"

NOTICE: An asterisk (*) following the number or letter designating a subdivision indicates explanatory material on that subdivision in Appendix A.

Chapter 1 General Information

S-1-1 Scope. This standard deals with the design and installation of Automatic Dwelling Sprinkler Systems.

S-1-2 Purpose. *The purpose of this standard is to provide a sprinkler system that will aid in the detection and control of dwelling fires.* The system is to provide protection against injury, life loss and property damage.

S-1-3 Definitions

S-1-3.1 One and Two Family Dwelling means any building which contains one or two "dwelling units" intended to be used, rented, leased, let or hired out to be occupied, or which are occupied for living purposes.

S-1-3.2 Multiple Family Dwelling means any building which contains more than two "dwelling units".

S-1-3.3 Dwelling Unit means a building, part of a *building or other shelter providing complete, independent living facilities for one or more persons including permanent provisions for living, sleeping, eating, cooking and sanitation.*

S-1-3.4 Sprinkler System means an integrated system of piping connected to a water supply, including a controlling valve and a device for actuating an alarm when the system operates, with listed sprinklers which will automatically initiate water discharge over a fire area.

S-1-3.5 Dwelling Sprinkler System means a sprinkler system which is:

- Connected to a water supply capable of producing 25 to 50 gpm for a 10 minute duration, depending on use of system.
- Designed, installed and tested in accordance with the requirements of this standard.
- Without a fire department connection.

A Dwelling Sprinkler System may be used to protect:

- Living spaces and storage spaces in one or two family dwellings.
- Automobile parking garages connected to one and two family dwellings.
- Attics and concealed spaces in one and two family dwellings.
- Living spaces in multiple family dwellings.
- Storage spaces in multiple family dwellings which do not exceed 300 sq. ft. in area.
- Common areas (such as work rooms, recreation rooms, laundry rooms, etc.) and service areas (boiler room, janitors area etc.) in multiple family dwellings which do not exceed 300 sq. ft. in area.
- Inaccessible attics or concealed spaces over individual living units in multiple family dwellings which do not exceed the plan view area of the living unit.
- Public circulation areas in multiple family dwellings.

A Dwelling Sprinkler System shall not be used to protect any other type of space.

S-1-3.6 Listed means that the equipment or material is included in a list published by a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

S-1-3.7 Wet System means a system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by a fire.

S-1-3.8 Dry System means a system employing automatic sprinklers attached to a piping system containing air under pressure slightly higher than atmospheric. Loss of air pressure from the opening of a sprinkler causes the release of water into the piping system and out the opened sprinkler.

S-1-4* Maintenance. *A sprinkler system installed under this standard shall be maintained in proper working order* and kept in normal automatic operation.

S-1-5 Design and Installation.

S-1-5.1 Devices and Materials.

S-1-5.1.1* Only new, listed sprinklers shall be used in residential sprinkler systems. Sprinklers shall have a nominal orifice size of 1/2 inch.

S-1-5.1.2 Water tanks, pumps, piping, piping hangers, and water control valves are not required to be listed. Water flow detection devices shall be listed.

S-1-5.1.3 All systems shall be tested for leakage at normal system operating water pressure.*

S-1-6 System Plans and Permit. Schematic system plans shall be submitted to the local building department for approval and issuance of an installation permit before any part of the system is installed. Those plans shall show the entire system from the point of connection to the water supply. All pipe sizes, supporting hydraulic calculations, sprinkler locations, drains and valves, shall be shown on the plans.

S-1-7 System Acceptance. The system shall be considered complete when the building department conducts a final inspection of the completed system and issues a completion certificate terminating the installation permit.

Chapter 2 Water Supply

S-2-1 General Provisions. *Every automatic residential sprinkler system shall have at least one automatic water supply. When stored water is used as the sole source of supply, the minimum quantity shall be* sufficient to supply the system water demand (S-3-1.2) for at least 10 minutes (250-500 gallons).

S-2-2 Water Supply Sources

S-2-2.1 Water supply connections direct from city water mains or combination domestic - automatic sprinkler connections shall be an acceptable water supply source.*

S-2-2.1.1 When sprinkler systems are directly connected to a potable water supply, a rubber-faced check valve shall be installed on the discharge side of the control valve.

S-2-2.1.2 Meters are not recommended for use in sprinkler systems.*

S-2-2.2 A tank shall be an acceptable water supply source. The tank shall be provided with a low water level alarm which will sound when the water level drops below the minimum (2-1).

S-2-2.3 A water source (tank or city connection) and automatically operated booster pump shall be an acceptable water supply.

Chapter 3 System Design

S 3-1 Hydraulic Design Criteria.

S-3-1.1 Application Rate. *The minimum design density (rate of water application) shall be 0.10 gallons per minute per sq. ft. (gpm/sq. ft.)* for a single sprinkler operating; and 0.05 gpm per sq. ft. for two sprinklers operating.

EXCEPTION: The minimum design density in storage spaces, common areas and service areas in multiple family dwellings shall be 0.16 gpm/sq. ft.

S-3-1.2 Water Demand. The water demand shall be 25 gpm or the largest room in square feet multiplied by 0.10 gpm per sq. ft., whichever is less.

EXCEPTION: The water demand in multiple family dwellings with storage spaces, common areas or service areas shall be 25 gpm or 0.16 gpm per sq. ft. x area (sq. ft.) of largest such space, whichever is greater.

S-3-1.3 Sprinkler Coverage

3-1.3.1 Standard sprinklers shall be mounted at the ceiling and spaced so that the maximum area protected by single sprinkler does not exceed 256 sq. ft.

EXCEPTION: Sprinklers protecting storage spaces, common areas and service areas in multiple family dwellings and sprinklers installed in unfinished spaces (no ceiling) in both one and two family and multiple family dwellings shall be located so that the maximum area protected by a single sprinkler does not exceed 130 sq. ft.

S-3-1.3.2 The maximum distance between ceiling mounted sprinklers shall not exceed 16 ft. on or between pipe lines and the maximum distance from a sprinkler to a wall or partition shall not exceed 8 ft.

S-3-1.3.3 Ceiling mounted sprinklers shall be located so that the distance between the sprinkler deflector and the ceiling is between 1 inch and 6 inches.

S-3-1.3.4 Sidewall sprinklers shall be spaced so that the maximum area protected by a single sprinkler does not exceed 256 sq. ft.

EXCEPTION: Sprinklers protecting storage spaces, common areas and service areas in multiple family dwellings and sprinklers installed in unfinished spaces (no ceiling) in both one and two family and multiple family dwellings shall be located so that the maximum area protected by a single sprinkler does not exceed 130 sq. ft.

S-3-1.3.5 The maximum distance between sidewall sprinklers mounted along the same wall shall not exceed 16 ft. The maximum distance from a sprinkler to an adjacent corner shall not exceed 8 ft. The maximum projected throw shall not exceed 16 ft.

S-3-1.3.6 Sidewall sprinklers shall be mounted so that the maximum distance between the deflector and the ceiling is between 1 inch and 6 inches.

S-3-1.3.7 Where no ceiling is used (unfinished spaces), sprinklers shall be located so that the deflector is between 1" and 6" below the bottom of the joists. Sprinklers shall also be located so that the deflector is not more than 1" above the bottom of any obstruction (air duct, beam) which is within 4 feet of the sprinkler.

S-3-1.3.8 Special sprinklers may be installed with larger protection areas or distances between sprinklers when such installations are made in accordance with the listings of a nationally recognized testing laboratory.

S-3-1.4 Pipe Sizing.

S-3-1.4.1 Piping shall be sized in accordance with 3-1.4.2 and 3-1.4.3 unless piping has been hydraulically calculated to achieve the design density specified in 3-1.1. When piping is sized hydraulically, calculations shall be made in accordance with the methods prescribed in NFPA #13, Standard for the Installation of Sprinkler Systems (See Appendix B).

S-3-1.4.2* *To size piping for systems connected to a city water supply* in which the water demand (3-1.2) does not exceed 25 gpm, *the following approximate method is acceptable:*

(a) Determine water pressure in the street

(b) Arbitrarily select pipe sizes.

(c) Deduct meter losses (See Table 3-1.4.2(c)).

(d) Deduct loss for elevation (height to highest sprinkler head in feet x 0.434 = (psi)).

(e) Deduct losses from street to control valve by multiplying the factor from Table 3-1.4.2(a) by the total length of pipe in feet.

Table 3-1.4.2(a)

Design Factors (PSI/Feet) with 25 GPM Flow

Pipe Size Inches	*Steel (c = 120)*	*Copper (c = 140)*
3/4	*0.64*	*0.52*
1	*0.20*	*0.14*
1-1/4	*0.05*	*0.05*
1-1/2	*0.02*	*0.02*
2	*0.008*	*0.004*

(f) Deduct losses for piping within building by multiplying factor from Table 3-1.4.2(a) by the total length in feet of each size of pipe between the control valve and the furthest sprinkler.

(g) Deduct valve and fitting losses. Count the valves and fittings from the control valve to the furthest sprinkler. Determine the equivalent length for each valve and fitting as shown in Table 3-1.4.2(b) and add these values to obtain the total equivalent length for each pipe size. Multiply the equivalent length for each size by the factor from Table 3-1.4.2(a) and total these values.

(h) In multi-level buildings, Steps (a) through (f) shall be repeated to size piping for each floor.

(i) If the remaining pressure is less than 20 psi, pipe or meter size shall be increased. If this pressure is substantially greater, it may be possible to decrease piping or meter size.

(j) The remaining piping shall be sized the same as the piping to the furthest sprinkler unless smaller sizes are justified by calculations.

EXCEPTION: For dwellings manufactured off-site, the minimum pressure needed to satisfy the system design criteria on the system side of the meter shall be specified on a data plate by the manufacturer.

S-3-1.4.3 To size piping for systems with an elevated tank, pump or pump tank combination, determine the pressure at the water supply outlet and proceed through Steps (b), (d), (f), (g), (h), (i) and (j) of 3-1.4.2.

S-3-1.4.4 To size piping for systems in which the water demand (3-1.2) exceeds 25 gpm, calculations shall be made in accordance with the methods prescribed in NFPA Standard #13.

Table 3-1.4.2 (b)

***Equivalent Length of Pipe in Feet For Fittings and Valves**

Fitting/Valve Diameter Inches	*Elbows*			*Tees*		*Valves*					
	45 Degrees	*90 Degrees*	*Long Radius*	*Flow Thru Branch*	*Flow Thru Run*	*Gate*	*Angle*	*Globe*	*Globe "Y" Pattern*	*Cocks*	*Check*
¾	1	2	1	4	1	1	10	21	11	3	3
1	1	3	2	5	2	1	12	28	15	4	4
1¼	2	3	2	6	2	2	15	35	18	5	5
1½	2	4	3	8	3	2	18	43	22	6	6
2	3	5	3	10	3	2	24	57	28	7	8

Based on Crane Technical Paper No. 410.-

*Excerpted from NFPA Std. 13-D - 1975 Edition

**Table 3-1.4.2 (c)

Pressure Drop in Meters

Meter Size, (Inches)	*Pressure Loss* at 25 gpm (psi)*
⅝	28.0
¾	10.0
1	3.6
1½	1.2
2	Less than 1.0
3	Negligible

*From Appendix B — Chart 1, National Standard Plumbing Code, National Association of Plumbing-Heating-Cooling Contractors, 1973 Edition, Page B-19.

** Excerpted from NFPA Std. 13-D - 1975 Edition

***Figure A-3-1.4.2(a). Calculation Sheet

	Individual Loss	Net Total
a. Water Pressure in Street (Static Gauge Pressure) _____		_____
b. Arbitrarily Select Pipe Size _____		
c. Deduct Meter Loss (___ Size) _____	_____	_____
d. Deduct Loss for Elevation (____ ft. x .434) _____	_____	_____
e. Deduct Loss From Street to Sprinkler System Control Valve*		
_____ Pipe – _____ ft.		
_____ Valves – _____ ft.		
___ ___ Elbows – _____ ft.		
_____ Tee – _____ ft.		
Total – _____ ft. x ._____	_____	_____
f. Deduct Loss for Piping – Control Valve to Farthest Sprinkler		
_____" Size, _____ ft. x ._____		
_____" Size, _____ ft. x ._____ = _____	_____	_____

g. Deduct Valve and Fitting Losses, Sprinkler System Control Valve to Farthest Sprinkler**

Size	Quan.	Description	Total Equiv. Feet
	_____	90° Elbow	_____
	_____	45° Elbow	_____
	_____	Tee	_____
	_____	Check Valve	_____
	_____	Valve (____)	_____
		Total	Ft. x ._____ = _____ _____

Size	Quan.	Description	Total Equiv. Feet
	_____	90° Elbow	_____
	_____	45° Elbow	_____
	_____	Tee	_____
	_____	Check Valve	_____
	_____	Valve (____)	_____
		Total	Ft. x ._____ = _____ _____

Remaining Pressure Must be at Least 20 PSI _____

*Factors from Table 3-1.4.2(a) **See Table 3-1.4.2(b)

*** *Excerpted from NFPA Std. 13-D - 1975 Edition*

**Figure A-3-1.4.2(b). Calculation Sheet - Elevated Tank, Booster Pump, Pump-Tank Supply

	Individual Loss	*Net Total*
Pressure at Water Supply Outlet	.....	.....
a. Deduct Loss for Elevation (—ft. x .434)	.....	.....
b. Deduct Loss from Piping Within Building* . .	.....	.....
Remaining Pressure Must be at Least 20 Psi	.....	.....

*Factors from Table 3-1.4.2(a).

** Excerpted from NFPA Std. 13-D - 1975 Edition

S-3-1.5 System Types.

S-3-1.5.1 Wet Pipe Systems. A wet pipe system shall be used when all piping is installed in areas not subject to freezing.

S-3-1.5.2 Dry Pipe Systems.

(a) Where system piping is located in unheated areas subject to freezing, dry pipe systems shall be used. Anti-freeze type systems shall not be permitted.

(b Dry pendent type sprinkler heads or upright sprinkler heads shall be used to prevent trapped water in parts of the system which may be subject to freezing conditions.

(c) Dry pipe system shall be controlled by a solenoid or pneumatic water supply control valve and a two-stage pressure detector switch which senses the air pressure in the system. The maximum air pressure shall be 10 psi and the pressure switch shall be set to allow an alarm when the air pressure drops to 5 psi. The valve shall be set to open when the air pressure is reduced to 3 psi. The solenoid valve must be fail-safe so that in the event of electric power outage, the valve will remain closed until opened manually.

S-3-2 Sprinklers.

S-3-2.1 This standard permits the use of listed standard and sidewall sprinklers, listed quick response sprinklers, listed extended coverage sprinklers and listed on-off type sprinklers.

S-3-2.2 Intermediate temperature-rated sprinklers (175 degree to 225 degree F.) shall be used in attics, furnace rooms, concealed spaces and elsewhere where normal temperatures may exceed 100 degrees F. Ordinary temperature-rated sprinklers (135 degree to 170 degree F.) shall be used in all other areas.

S-3-2.3 *Sprinklers shall be installed at all* occupiable or useable areas.

EXCEPTION #1: Sprinklers may be omitted from bathrooms.

EXCEPTION #2: Sprinklers may be omitted from small closets where the area does not exceed 24 sq. ft. and the least dimension does not exceed 3 ft.

EXCEPTION #3: Sprinklers may be omitted from open attached porches, carports, garages and similar unheated attached structures.

EXCEPTION #4: Sprinklers may be omitted from attics in one and two family dwellings which are not used or intended for living purposes or storage.

EXCEPTION #5: Sprinklers may be omitted from entrance foyers and hallways which are not the only means of emergency egress.

S-3-3 Piping.

S-3-3.1 Pipe or tube used in sprinkler systems shall be of the materials in Table 3-3.1 or in accordance with 3-3.2 through 3-3.7. The chemical properties, physical properties and dimensions of the materials listed in Table 3-3.1 shall be at least equivalent to the standard cited in that Table and designed to withstand a working pressure of not less than 175 psi.

* Table 3-3.1

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
Welded and Seamless Steel Pipe for Ordinary Uses, Specification for Black and Hot-Dipped Zinc Coated (Galvanized)	ASTM A120–72a
Specification for Welded and Seamless Steel Pipe	ASTM A53–72a
Wrought-Steel Pipe	ANSI B36.10–70
Copper Tube (Drawn, Seamless)	
Specification for Seamless Copper Tube	ASTM B75–72 or
Specification for Seamless Copper Water Tube	ASTM B88–72
Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B251–72
Brazing Filler Metal (Classification BCuP-3 or BCuP-4)	AWS A5.8–69
Solder Metal, 95–5 (Tin-Antimony-Grade 95TA)	ASTM B32–70

* Excerpted from NFPA Std. 13-D - 1975 Edition

S-3-3.2 Standard wall Schedule 40 pipe is permitted.

S-3-3.3 Copper tube shall have a wall thickness of Type K, L or M.

S-3-3.4 Other types of pipe or tube may be used, but only those investigated and listed for Residential Sprinkler System service by a nationally recognized testing and inspection agency laboratory.

S-3-3.5 Whenever the word "pipe" is used in the standard, it shall be understood to also mean "tube".

S-3-3.6 Thinwall steel pipe with a wall thickness of 0.120 inches may be joined with a mechanical grooved coupling approved for service with grooves rolled on the pipe by an approved groove rolling machine.

S-3-3.7 Fittings used in sprinkler systems shall be of the materials listed in Tables 3-3.7 or in accordance with 3-3.9. The chemical properties, physical properties and dimensions of the materials listed in Table 3-3.7 shall be at least equivalent to the standard cited in the Table. Fittings used in sprinkler systems shall be designed to withstand the working pressures involved, but not less than 175 psi cold water pressure.

* Table 3-3.7

Material and Dimensions	Standard
Cast Iron	
Cast Iron Screwed Fittings 125 and 250 lb.	ANSI B16.4–1971
Cast Iron Pipe Flanges and Flanged Fittings	ANSI B16.1–1967
Malleable Iron	
Malleable Iron Screwed Fittings, 150 and 300 lb.	ANSI B16.3–1971
Steel	
Factory-Made Wrought Steel Buttweld Fittings	ANSI B16.9–1961
Buttwelding Ends for Pipe, Valves, Flanges and Fittings	ANSI B16.25–1972
Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	ASTM A234–73
Steel Pipe Flanges and Flanged Fittings	ANSI B16.5–1973
Forged Steel Fittings, Socket Welded and Threaded	ANSI B16.11–1973
Copper	
Wrought Copper and Bronze Solder-Joint Pressure Fittings	ANSI B16.22–1973
Cast Bronze Solder Joint Pressure Fittings	ANSI B16.18–1972

*Excerpted from NFPA Std. 13-D - 1975 Edition

S-3-3.8 Joints for the connection of copper tube shall be brazed.

EXCEPTION: Soldered joints may be used for wet pipe copper tube systems.

S-3-3.9 Other types of fittings may be used, but only those investigated and listed for Residential Sprinkler System service by nationally recognized testing and inspection agency laboratory.

S-3-4 Valves and Drains.

S-3-4.1 Each system shall have an indicating type water control valve located immediately on the discharge side of its water supply.

S-3-4.2 Each sprinkler system shall have a 1/2 inch or larger drain connection with valve on the system side of the control valve. That drain valve shall be located so that the drain may function as a test connection (See Figure A-2-2.1).

S-3-4.3 Additional drains shall be installed at the low point of each trapped portion of a dry system. Those drains may be 1/2 inch brass plugs.

S-3-5 Pressure Gauges

S-3-5.1 A pressure gauge shall be installed on the system side of the control valve on a wet pipe system.

S-3-5.2 Each dry pipe system shall be provided with an air pressure gauge.

S-3-6 Piping Support

S-3-6.1* *Piping shall be supported from structural members.* This standard contemplates hanging methods comparable to those required by local plumbing codes.

S-3-6.2 Piping laid on open joists or rafters shall be secured to prevent lateral movement.

S-3-7* Alarms

S-3-7.1 Waterflow Alarms. Sprinkler systems shall be provided with a waterflow detecting device arranged to sound an alarm which will be audible in all living areas over background noise levels with all intervening doors closed.*

EXCEPTION: Local alarm bells are not needed if water flow alarm signals are incorporated into an overall building security/alarm system.

S-3-8 Pumps

S-3-8.1 Electric motor driven booster pumps capable of producing the water demand (3-1.2) at the necessary discharge pressure to satisfy the hydraulic demand of the system (3-1.4.3, 3-1.4.4) are permitted.

S-3-8.2 The pump shall be installed between the system control valve and the system check valve.

S-3-8.3 A pump by-pass with indicating control valve and check valve is permitted, but is not required.

S-3-8.4 The pump shall be started by closing a pressure switch which senses a 10 psi drop in the normal sprinkler system pressure.

S-3-8.5 The pump shall be provided with a means to manually start the pump.

S-3-8.6 The pump wiring shall be installed in accordance with the local electrical code and the National Electrical Code requirements pertaining to electric motor driven water supply pumps. The pump is not required to be wired as a "fire pump".

S-3-9 Electrical Wiring

S-3-9.1 All electrical wiring shall be installed in accordance with requirements of the National Electrical Code and the local electrical code.

S-3-9.2 All electrically operated equipment shall operate on normal house voltage.

APPENDIX A

S-A-1-4 *The owner is responsible for the condition of a sprinkler system and should keep the system in normal automatic operating condition.* A monthly inspection program should be conducted, including:

(a) Inspection of all valves to make certain that they are open.

(b) Checking the tank water level.

(c) Checking the water supply pressure gauge.

(d) Checking the dry system pressure gauge.

(e) Testing the waterflow alarm system.

(f) Operation of the pump.

If the waterflow alarm system is arranged to transmit a waterflow alarm signal directly to the fire department, the fire department should be notified prior to testing the alarms or starting the pump.

The owner should take care to see that sprinklers are not painted at the time of installation or during subsequent redecoration. When painting in areas next to sprinklers, the sprinklers may be protected by covering with a paper bag. The bag should be removed immediately after painting has been completed.

S-A-1-5.1.1 *At least one spare sprinkler of each type and temperature rating used in the system should be kept on the premises.* When fused sprinklers are replaced, care should be taken to assure that the replacement sprinkler is the correct type.

S-A-1-5.1.3 A system should be tested for leakage by filling the system with water and visually checking each joint or coupling.

Dry systems should be tested by placing the system under normal operating air pressure. Any leak which results in a 2 psi drop in system air pressure in a 24 hour period should be corrected. Leaks can be detected by using soapy water brushed on each joint or coupling.

All tests should be conducted prior to concealing the piping.

S-A-2-2.1 *Preferred and acceptable water supply arrangements are shown in Figure A-2-2.1. It is desirable to combine the sprinkler and domestic water supplies to assure that the city gate valve remains open.*

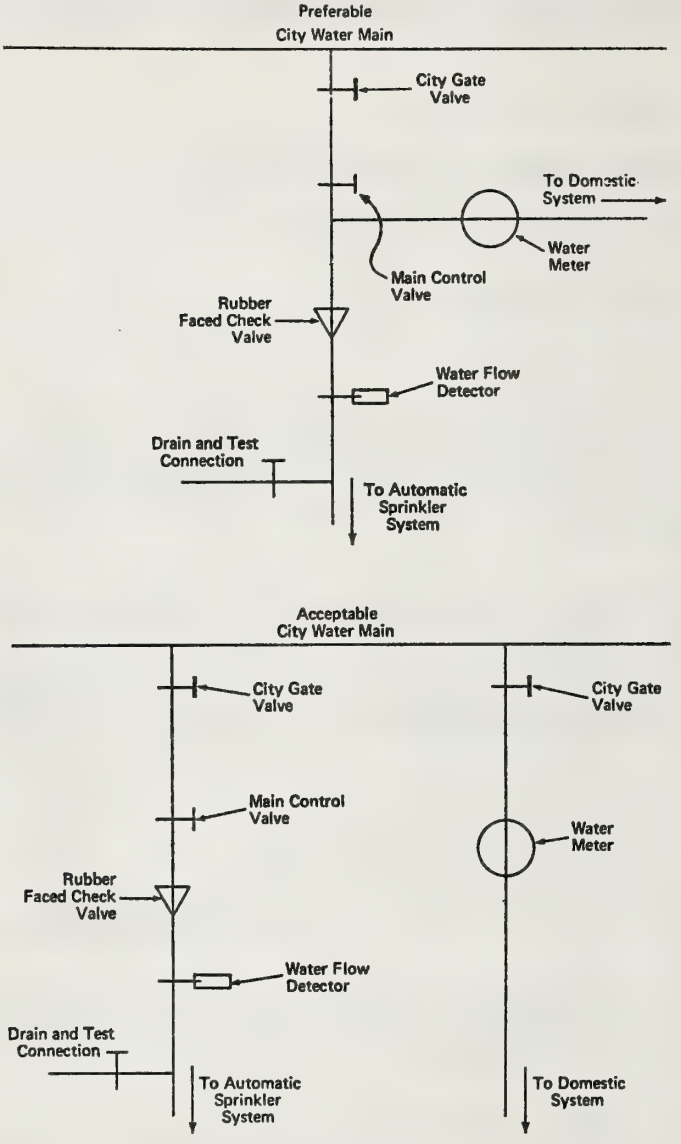

Figure A-2-2.1

S-A-2-2.1.2 When a meter must be used between the city water main and the sprinkler system supply, an acceptable arrangement is shown in Figure A-2-2.1.2. Under these circumstances, the flow characteristics of the meter must be included in the hydraulic calculation of the system (see Table 3-1.4.2(c)).

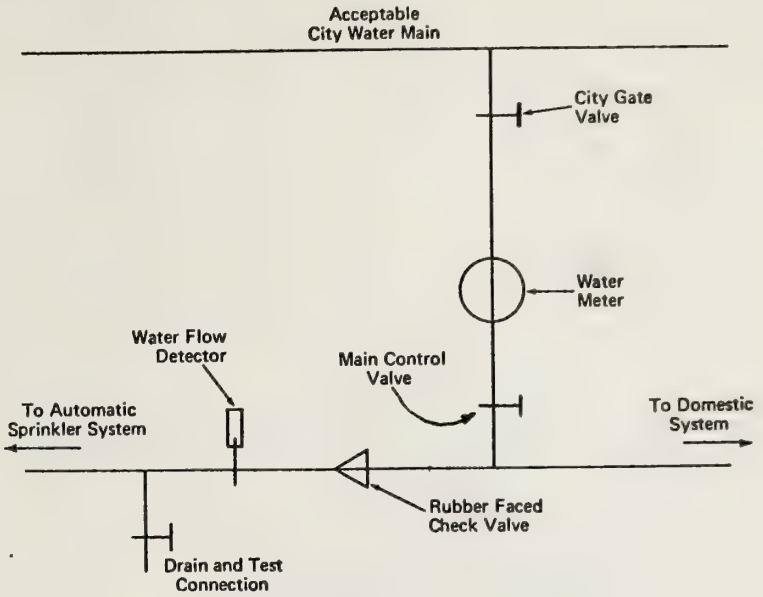

Figure A-2-2.1.2

S-A-3-2.3 For an increased level of life safety, automatic fire detection devices should be installed in areas which are not sprinklered. For an increased level of protection, sprinklers should be installed in all occupiable areas and smoke detectors should be installed outside all sleeping areas.

S-A-3-6.1 Support methods described in NFPA #13 Standard for Installation of Sprinkler Systems, are considered to be acceptable methods for use in this standard (See Appendix B).

S-A-3-7 Alarms may also be transmitted to a responding fire department when the fire department has provided for the receipt of such alarms.

S-A-3-7.1 Alarms should be of sufficient intensity to waken a sleeping person. The tests of audibility level should be conducted with all household equipment, which may be in operation at night, in full operation. Examples of such equipment are window air conditioners, room humidifiers or a forced air heating system.

REFER TO NFPA STD. 13-D - 1975 EDITION,

FOR

APPENDIX B; APPENDIX C

APPENDIX VI

Prototype - New Technology

Example Systems

APPENDIX VI

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VI-1 Example "A" - Reduced Cost Automatic Residential Sprinkler System

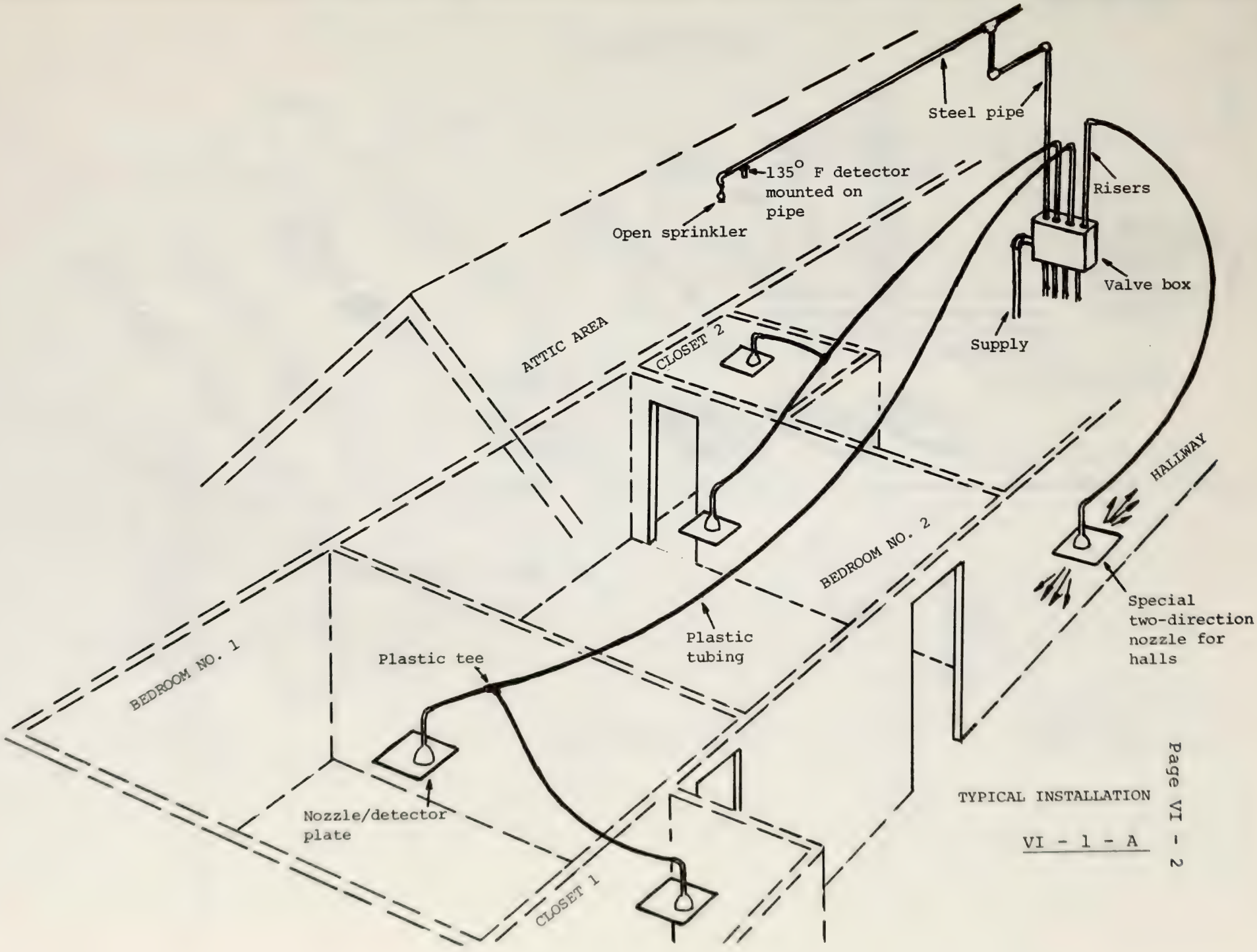
VI-1.1 This example system will reduce both installation and material costs. It is essentially a dry system, using a central control valve which is selectively activated by thermal detectors in the various rooms. (See Drawings VI-1 A & B.)

VI-1.2 The most expensive component is the control valve. It may be a cast metallic or injected molded plastic manifold with provisions for installing approximately ten solenoid valves. The valves would normally be closed with spring loaded poppet valves using Teflon coated steel to prevent sticking. Solenoids would be of the latching type and once opened, would remain open until manually reset. Each valve would be provided with a manual operator so that the system could be tripped manually. (See Drawing VI-1-C)

VI-1.3 The manifold and solenoid valve assembly would be housed in a substantial box or cabinet. Also included in the box would be the low voltage transformer for the thermal heat detectors and possibly a small booster pump and pressure switch. The box would have a lead sealed lock wire on its latch to prevent tampering. Valves inside the box would be identified as to function. (See Drawing VI-1-D)

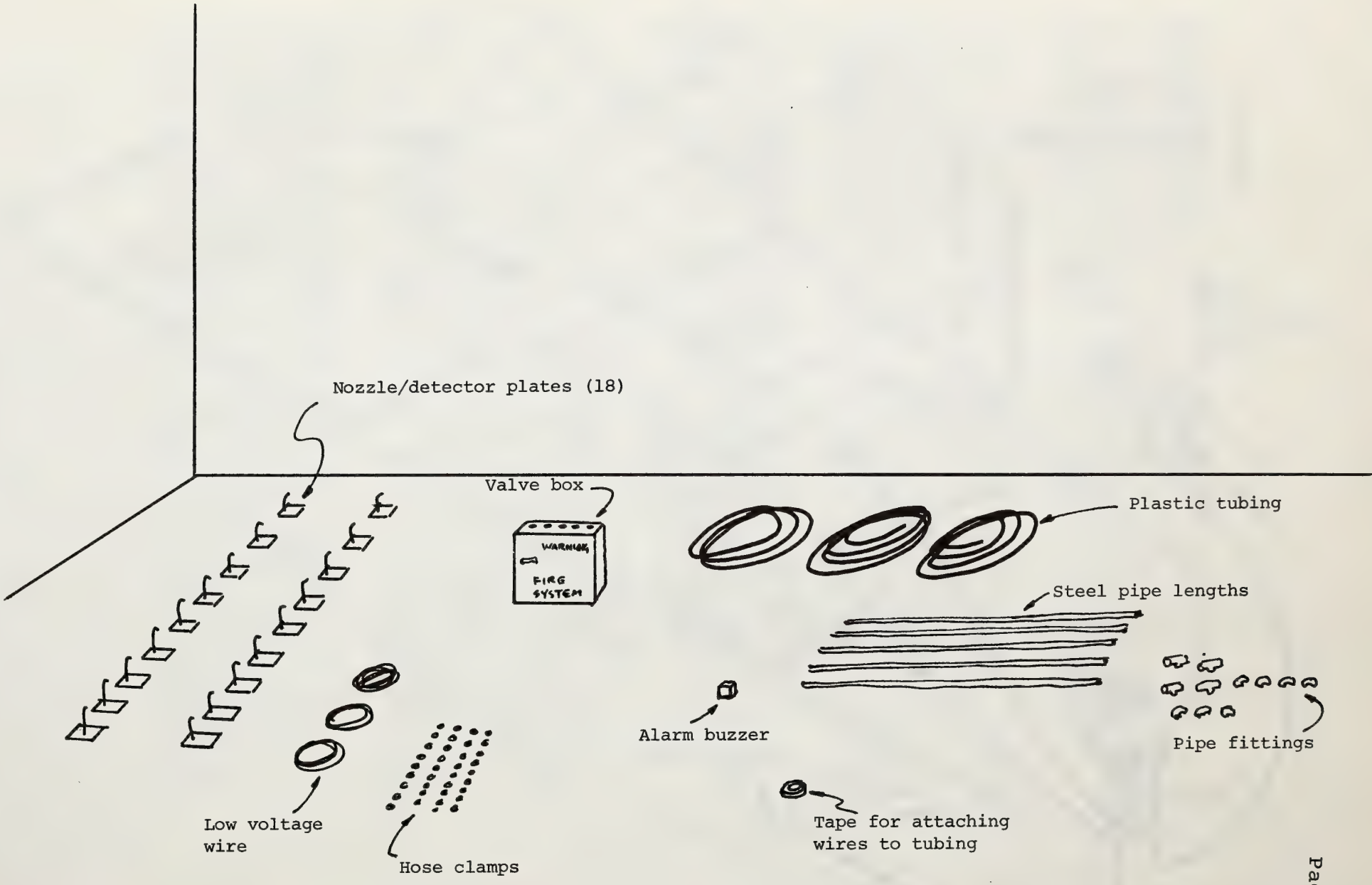
VI-1.4 The system piping would be a combination of steel pipe or copper tubing and rigid or flexible plastic tubing or hose. The plastic tubing would be used where it could be concealed behind a plaster or gypsum wall. Exposed piping supplying sprinklers in the attic or basement would be steel, copper or similar materials which could withstand moderate fire exposure without being damaged. The exposed piping in the attic and basement supplying the sprinklers for other areas of the residence may be either plastic or steel/copper because that pipe can be damaged by a fire without affecting the sprinkler protection in the attic or basement. (See Drawing VI-1-E)

VI-1.5 The detector/nozzle plate could consist of a decorative steel escutcheon plate approximately 10 inches square with an open nozzle orifice and deflector. The plate could also hold a bi-metallic thermal detector which would sense fire and call for activation of the valve supplying that nozzle. The back side of the plate could contain an enlarged portion with a screen to form a trap and a connection tube formed at a 90 degree angle to accept the plastic tubing. (See Drawing VI-1F, G and H)

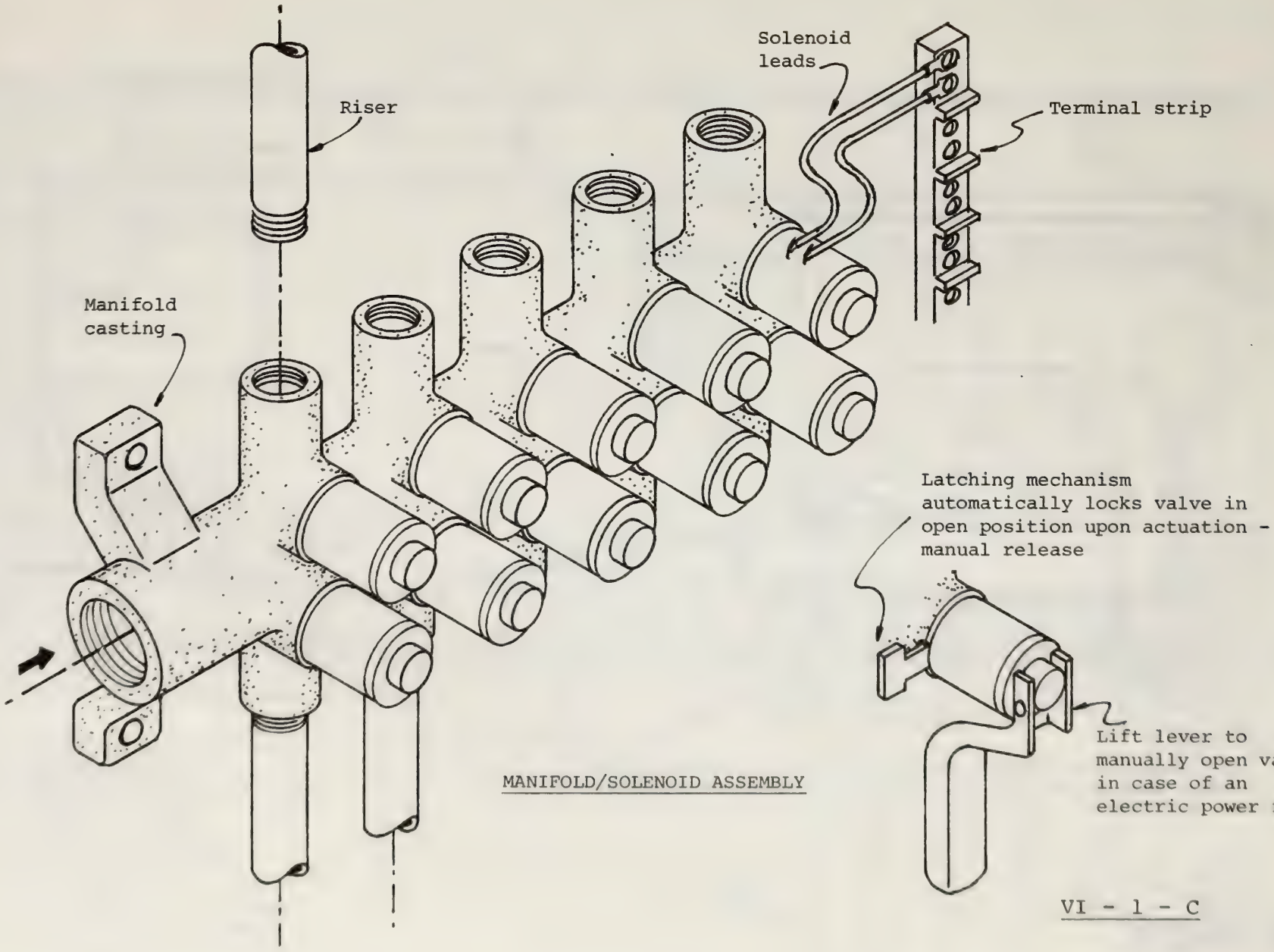


TYPICAL INSTALLATION

VI - 1 - A

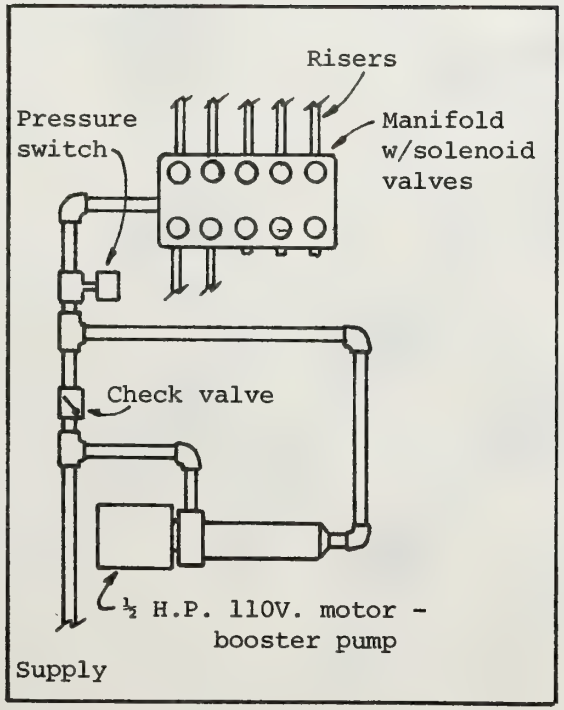


COMPONENTS OF SYSTEM

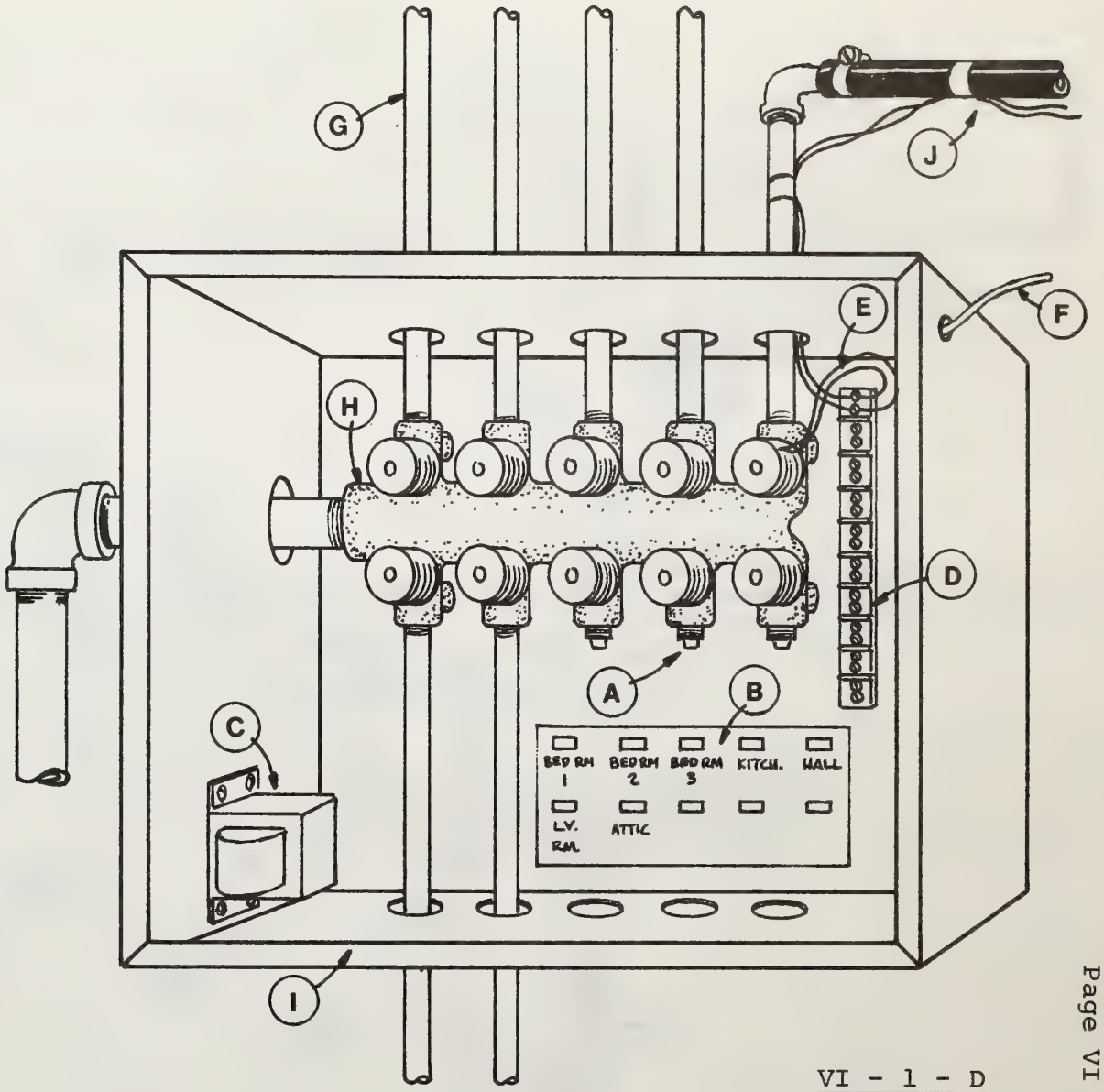

Riser
Solenoid leads
Terminal strip
Manifold casting
Latching mechanism automatically locks valve in open position upon actuation - manual release
Lift lever to manually open valve in case of an electric power failure

MANIFOLD/SOLENOID ASSEMBLY

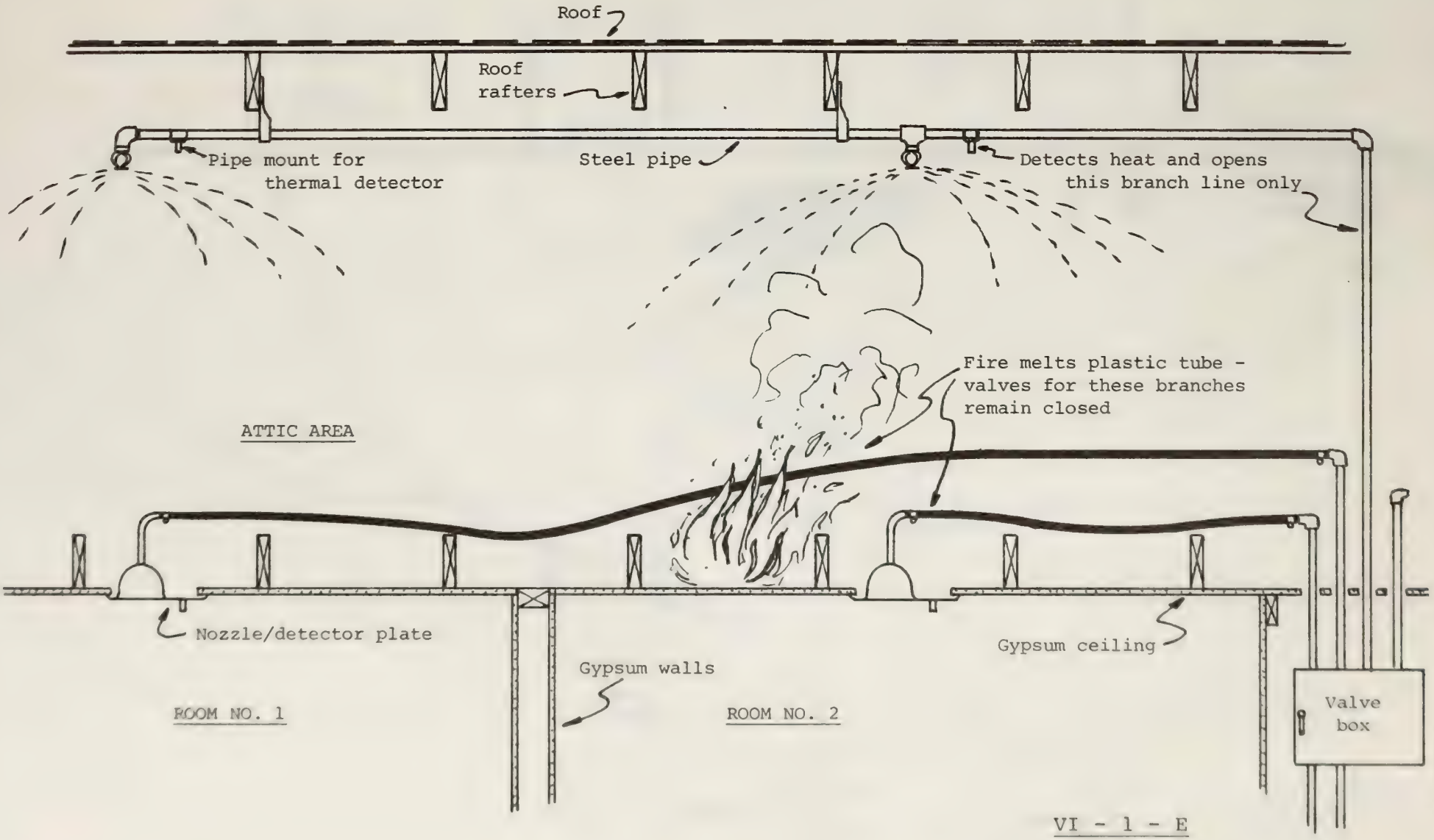
A - Un-used outlets plugged
B - Label w/code of risers
C - Low voltage transformer
D - Terminal strip
E - Pre-wired solenoids
F - To alarm in hall
G - Risers to rooms
H - Manifold w/solenoid valves
I - Steel cabinet
J - Tubing & wires to room



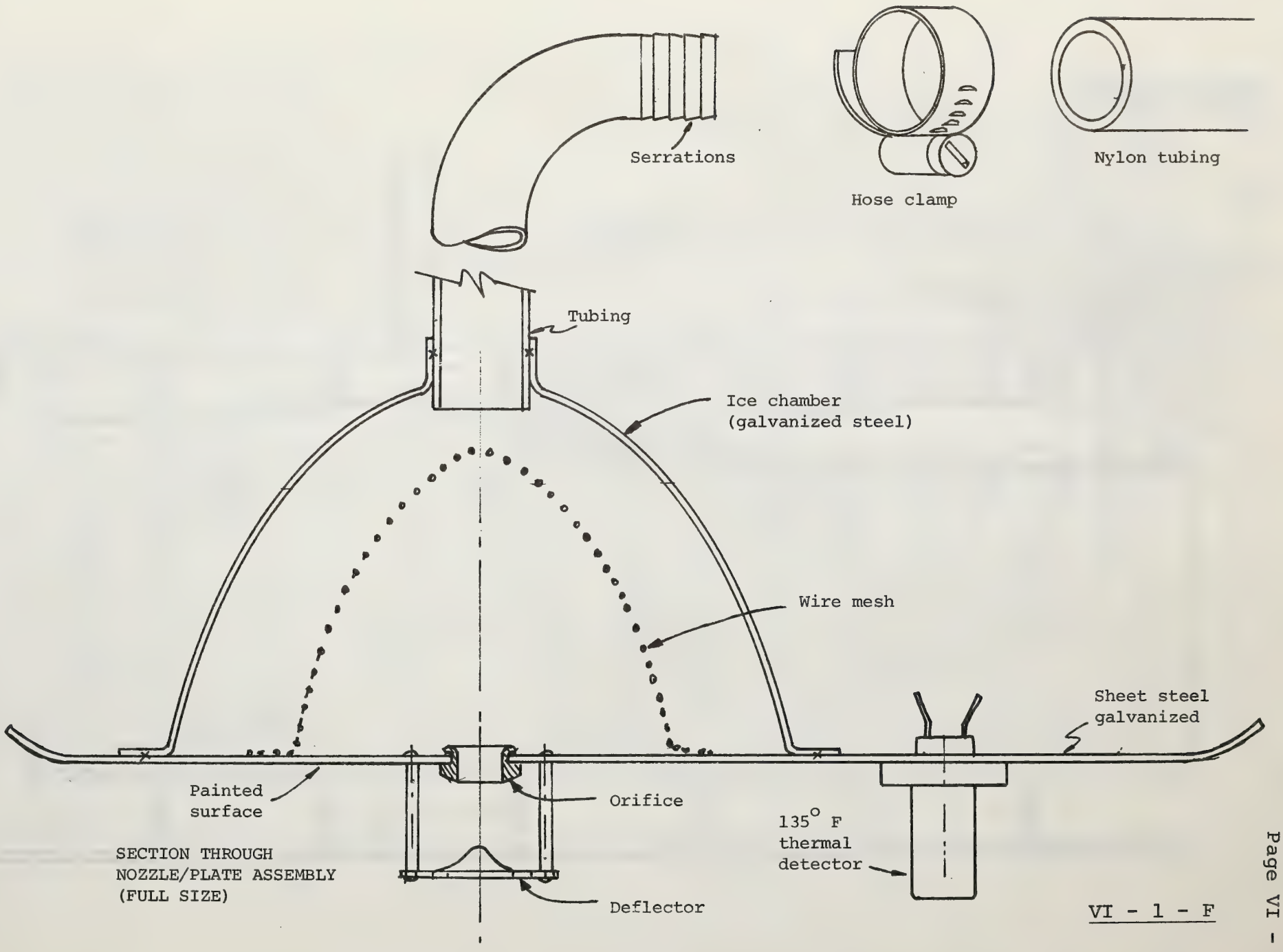
Booster Pump Detail



VI - 1 - D

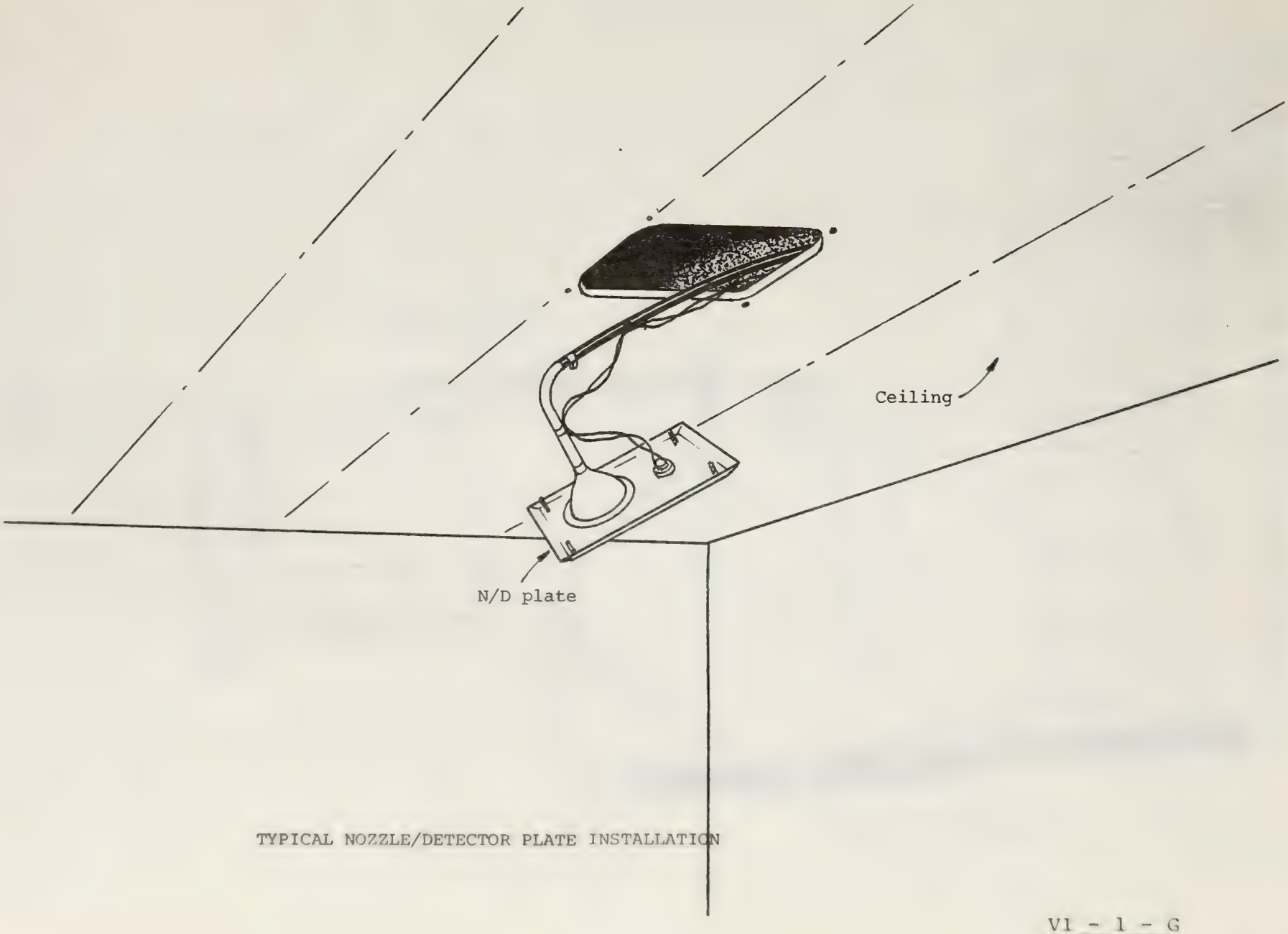

Roof
Roof rafters
Pipe mount for thermal detector
Steel pipe
Detects heat and opens this branch line only
Fire melts plastic tube - valves for these branches remain closed
ATTIC AREA
Nozzle/detector plate
Gypsum walls
Gypsum ceiling
ROOM NO. 1
ROOM NO. 2
Valve box

VI - 1 - E

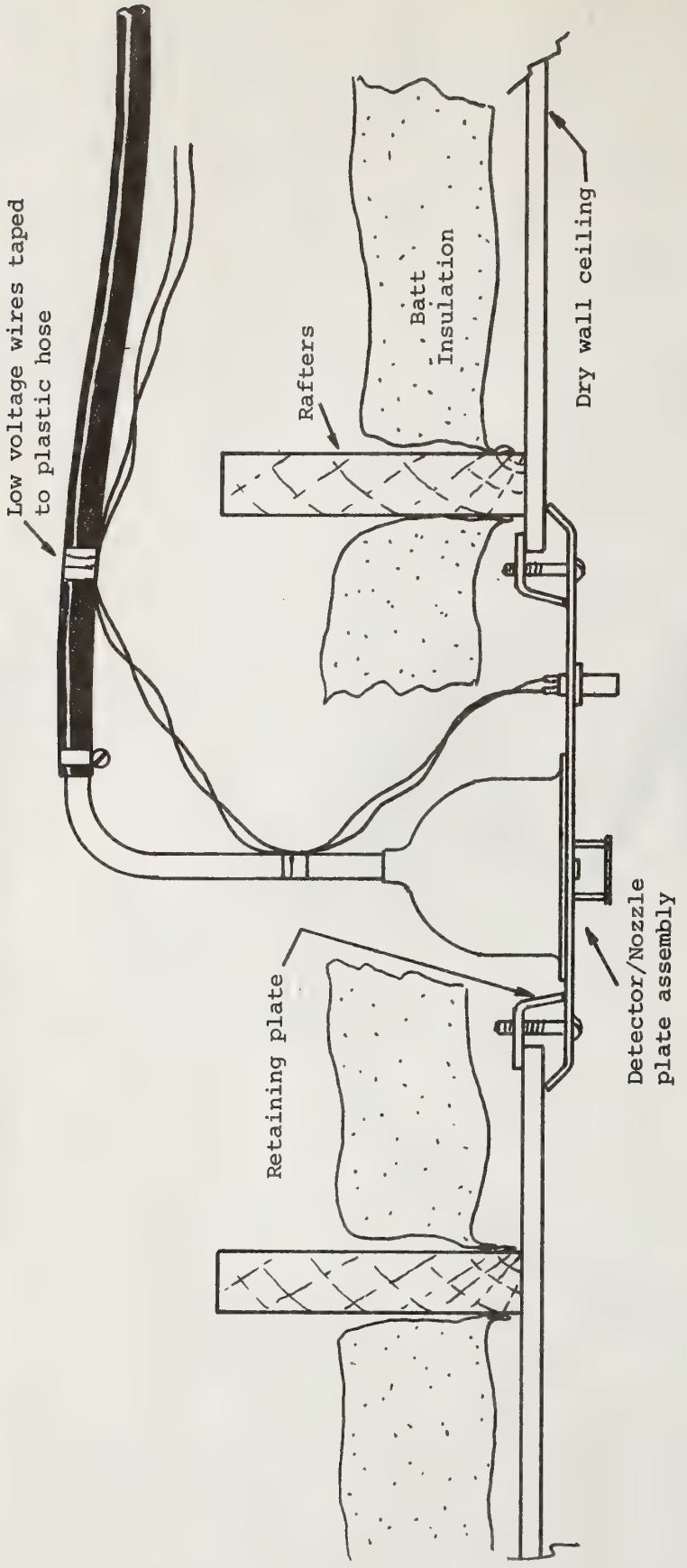


SECTION THROUGH
NOZZLE/PLATE ASSEMBLY
(FULL SIZE)

VI - 1 - F



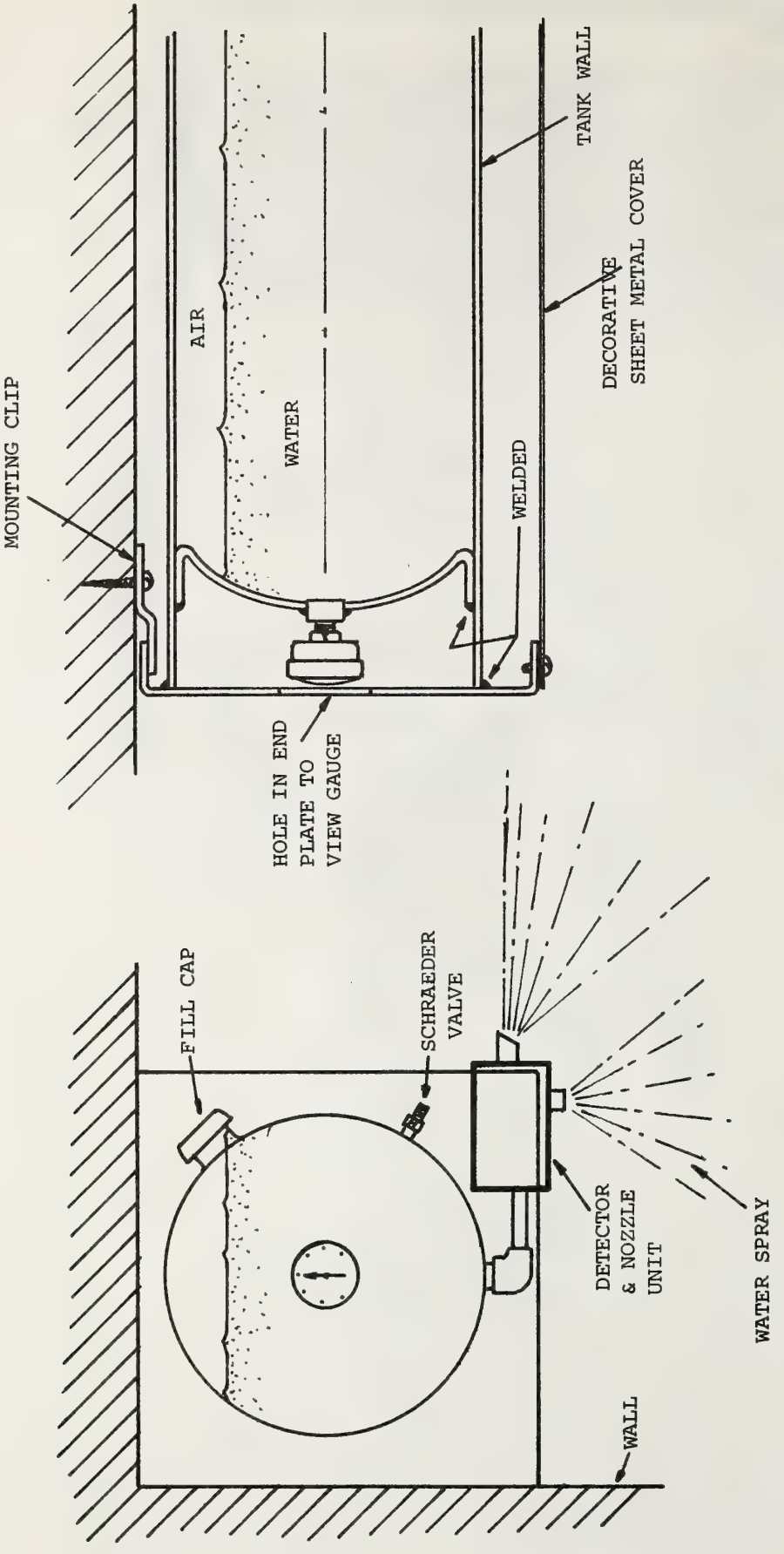
TYPICAL NOZZLE/DETECTOR PLATE INSTALLATION


Low voltage wires taped to plastic hose
Rafters
Batt Insulation
Dry wall ceiling
Retaining plate
Detector/Nozzle plate assembly

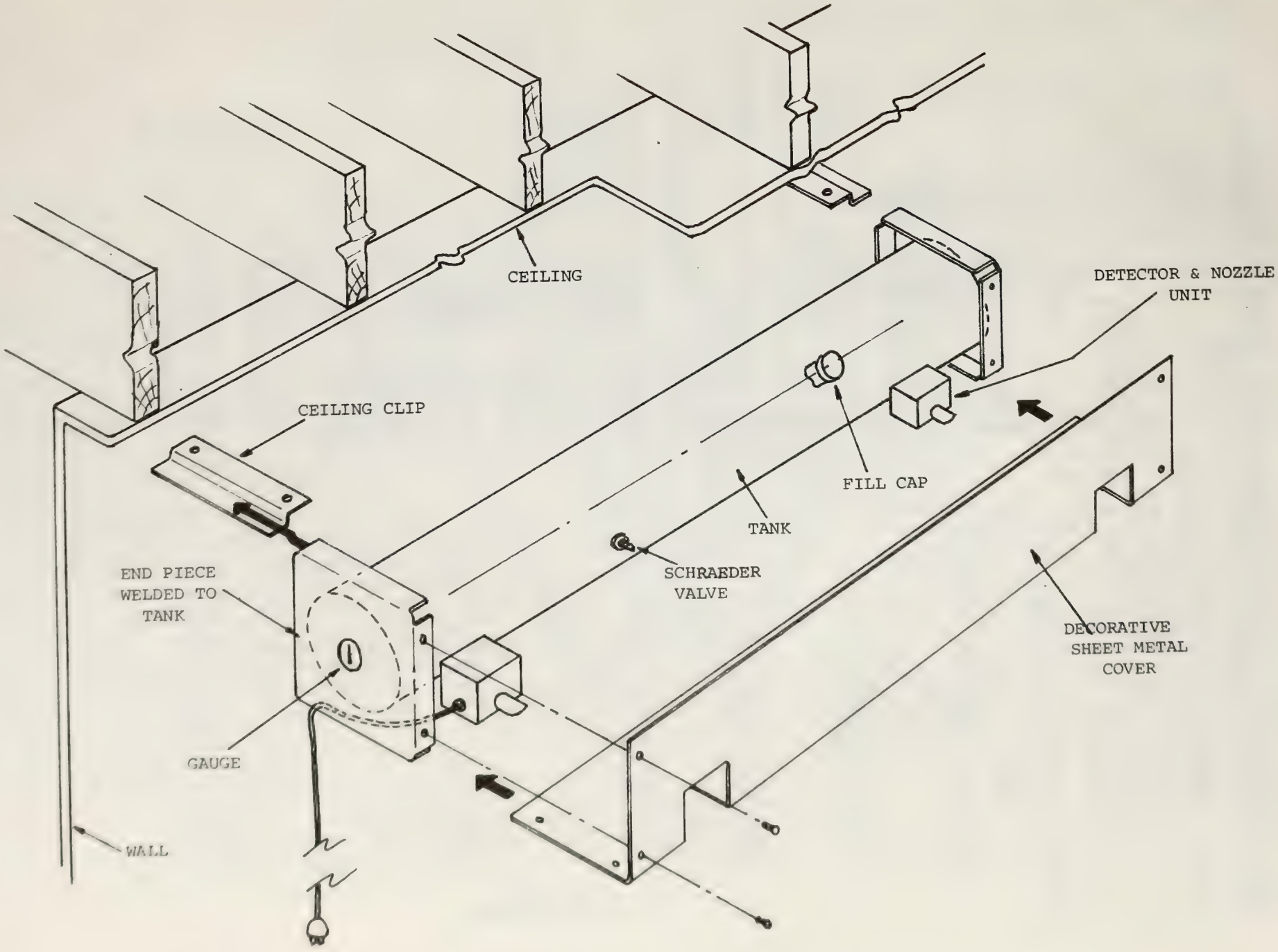
VI - 1 - H

VI-2 Example "B", Reduced Cost, Automatic Residential Sprinkler System.

This example system is a package-type system for use in existing residences. The water supply is contained in a tank which will be concealed behind a cove molding. The tank will normally be filled with water and pressurized. Upon system actuation, water will be discharged through small spray nozzles which are opened by mini detectors located near the nozzles. The discharge nozzles will be located along the room perimeter as the fuel concentrations in a room are also located near the room perimeter. (See drawing VI-2-A and B)


MOUNTING CLIP
AIR
WATER
TANK WALL
DECORATIVE SHEET METAL COVER
WELDED
HOLE IN END PLATE TO VIEW GAUGE
FILL CAP
SCHRAEDER VALVE
DETECTOR & NOZZLE UNIT
WATER SPRAY
WALL

VI - 2 - A


CEILING
DETECTOR & NOZZLE UNIT
CEILING CLIP
FILL CAP
TANK
SCHRAEDER VALVE
END PIECE WELDED TO TANK
DECORATIVE SHEET METAL COVER
GAUGE
WALL

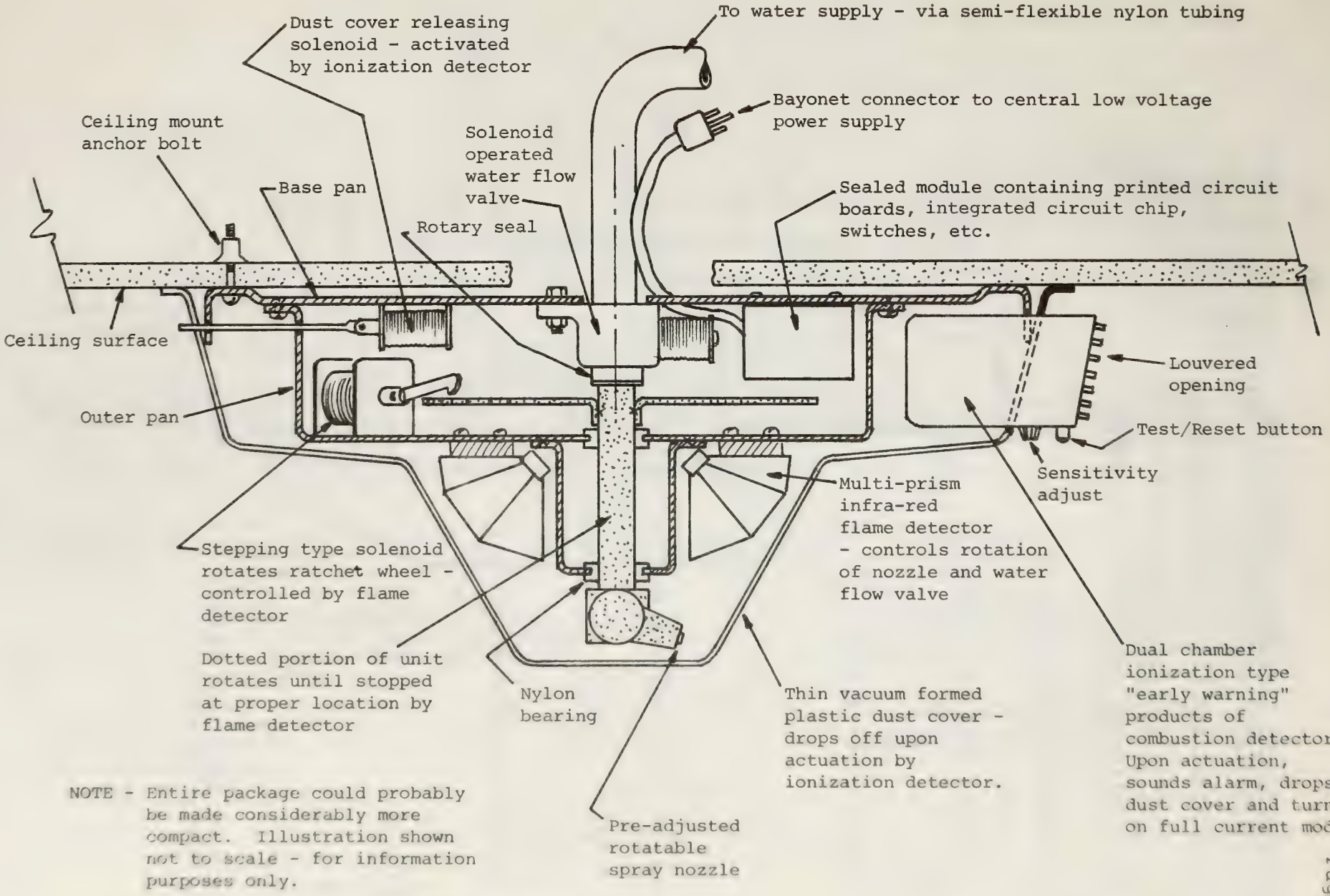
VI-3 Example "C" - Rotating, Directional, Variable Flow Rate, Smoke Sensitive Nozzle - Fixed Flame Detector

VI-3.1 Example "C" characteristics:

- o Ionization type incipient detector
- o Multi-prism "Bug eye" flame detector
- o Rotating-variable flow rate nozzle
- o Computer control

VI-3.2 Operating Sequence:

	Event	System Action
1.	Incipient detector senses fire in room.	o Local alarm sounded. o Cover released over "bug eye" and nozzle. o "Bug eye" activated.
2.	"Bug eye" sees fire in single zone.	o Nozzle directed at fire zone. o Water turned on at predetermined flow rate. o Alarm sent to fire department.
3.	"Bug eye" sees fire in additional zones.	o Nozzle is rotated to "sweep" each zone. o Waterflow rate increased in relation to number of zones.
4.	"Bug eye" sees fire in fewer zones.	o Nozzle sweep is adjusted to cover only those zones where fire is seen (time delay). o Waterflow rate is decreased in decreased in relation to the number of zones where fire is seen (time delay)
5.	"Bug eye" no longer sees fire.	o Water is shut off (time delay). o Nozzle sweep ends with nozzle aimed at zone where fire was last seen (time delay). o "Bug eye" continues to look for fire until system is manually reset.
6.	"Bug eye" sees fire again prior to system being reset.	o Water turned on. o Nozzle directed at fire zone.


To water supply - via semi-flexible nylon tubing
Dust cover releasing solenoid - activated by ionization detector
Bayonet connector to central low voltage power supply
Ceiling mount anchor bolt
Solenoid operated water flow valve
Base pan
Rotary seal
Sealed module containing printed circuit boards, integrated circuit chip, switches, etc.
Ceiling surface
Louvered opening
Outer pan
Test/Reset button
Sensitivity adjust
Multi-prism infra-red flame detector - controls rotation of nozzle and water flow valve
Stepping type solenoid rotates ratchet wheel - controlled by flame detector
Dotted portion of unit rotates until stopped at proper location by flame detector
Nylon bearing
Thin vacuum formed plastic dust cover - drops off upon actuation by ionization detector.
Dual chamber ionization type "early warning" products of combustion detector. Upon actuation, sounds alarm, drops dust cover and turns on full current mode.
Pre-adjusted rotatable spray nozzle

NOTE - Entire package could probably be made considerably more compact. Illustration shown not to scale - for information purposes only.

EXAMPLE -C

VI - 3 - A

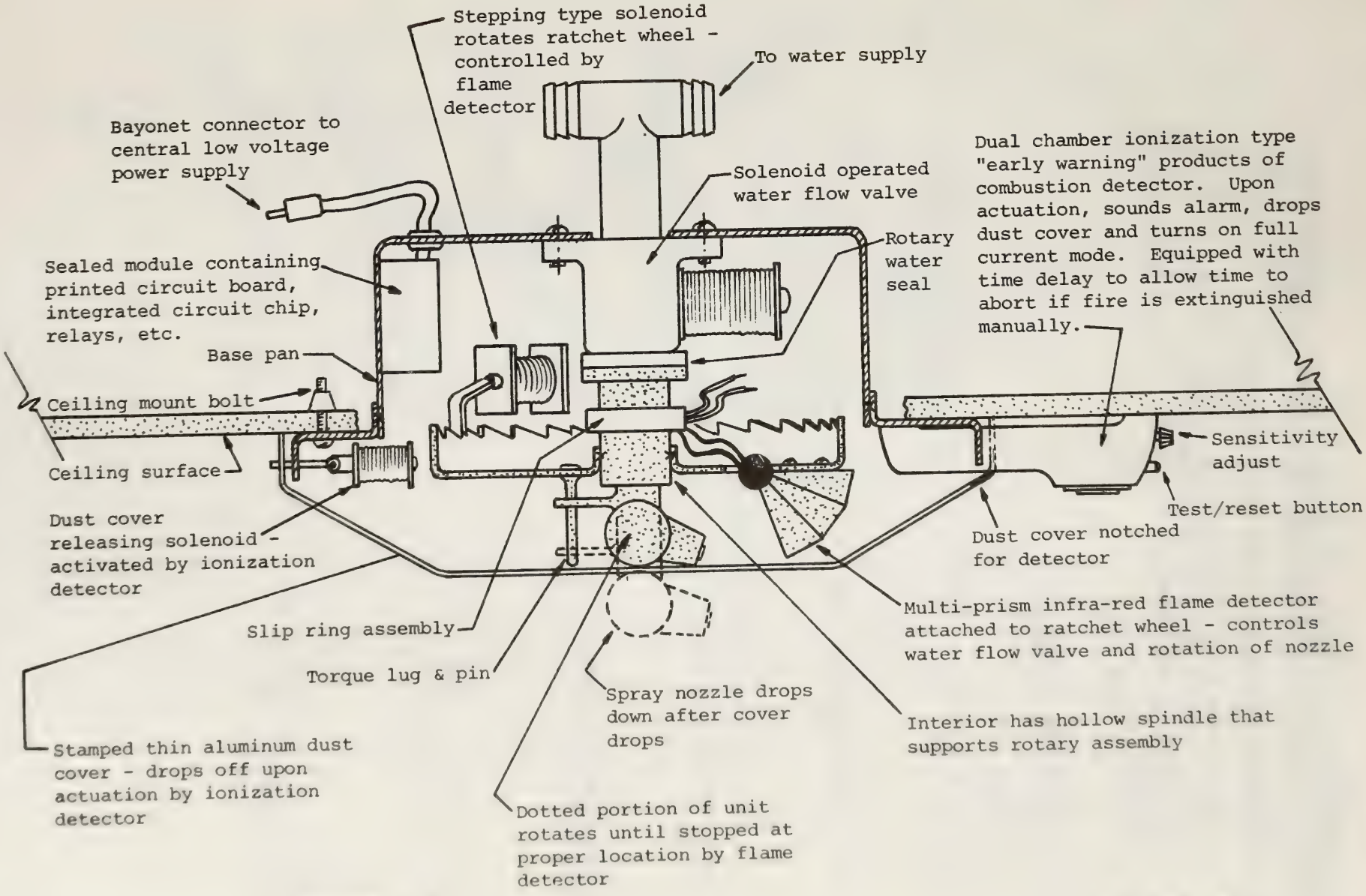
VI-4 Example "D" - Rotating, Directional, Variable Flow Rate, Smoke Sensitive Nozzle - Rotating Flame Detector

VI-4.1 Example System "D" characteristics:

- o Ionization type incipient detector
- o Rotating flame detector
- o Rotating-variable flow rate nozzle
- o Computer control

VI-4.2 Operating Sequence:

Event	System Action
1. Incipient detector senses fire in room.	o Local alarm sounded. o Cover released over scanner and nozzle. o Scanner activated.
2. Scanner detects fire.	o Nozzle directed to sweep fire area. o Water turned on - flow rate proportional to area of fire. o Alarm sent to fire department.
3. Scanner sees fire growing.	o Flow rate increased. o Nozzle sweep altered to cover enlarged fire area and to discharge ahead of fire.
4. Scanner sees fire declining.	o Flow rate decreased (time delay) o Nozzle sweep reduced (time delay)
5. Scanner sees no further fire.	o Water off (time delay) o Nozzle sweep stops (time delay) o Scanner continues to look for fire until manually reset.
6. Scanner sees fire again before being reset.	o Water turned on. o Nozzle directed to sweep fire area.


Stepping type solenoid rotates ratchet wheel - controlled by flame detector
To water supply
Bayonet connector to central low voltage power supply
Solenoid operated water flow valve
Dual chamber ionization type "early warning" products of combustion detector. Upon actuation, sounds alarm, drops dust cover and turns on full current mode. Equipped with time delay to allow time to abort if fire is extinguished manually.
Rotary water seal
Sealed module containing printed circuit board, integrated circuit chip, relays, etc.
Base pan
Ceiling mount bolt
Ceiling surface
Sensitivity adjust
Test/reset button
Dust cover releasing solenoid - activated by ionization detector
Dust cover notched for detector
Slip ring assembly
Multi-prism infra-red flame detector attached to ratchet wheel - controls water flow valve and rotation of nozzle
Torque lug & pin
Spray nozzle drops down after cover drops
Interior has hollow spindle that supports rotary assembly
Stamped thin aluminum dust cover - drops off upon actuation by ionization detector
Dotted portion of unit rotates until stopped at proper location by flame detector

EXAMPLE – D

VI - 4 - A

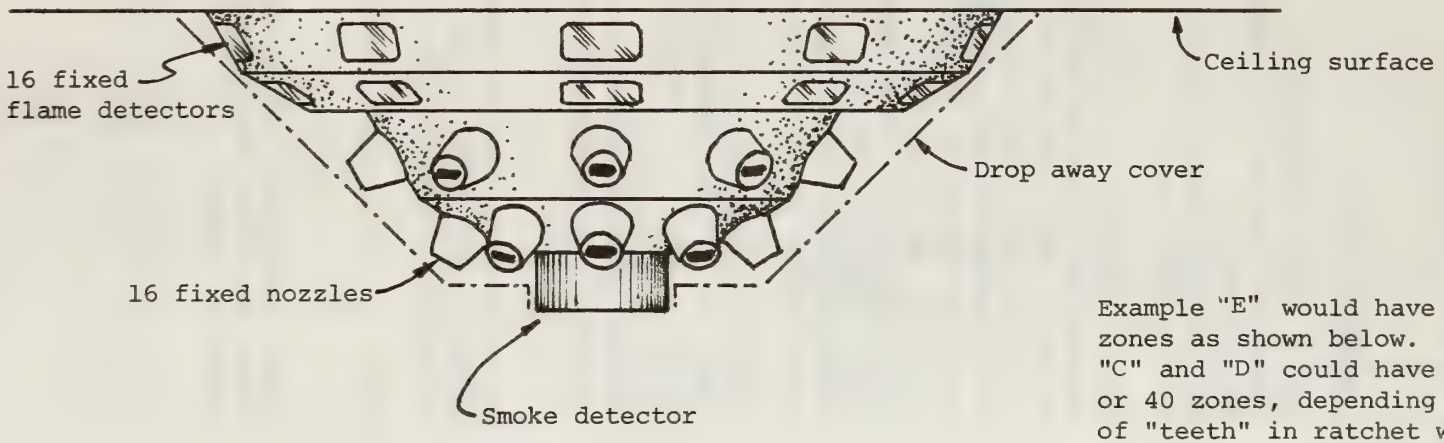
VI-5 Example "E" - Fixed, Multiple Orifice, Variable Flow Rate Smoke Sensitive Nozzle - Fixed Flame Detector

VI-5.1 Example System "E" characteristics:

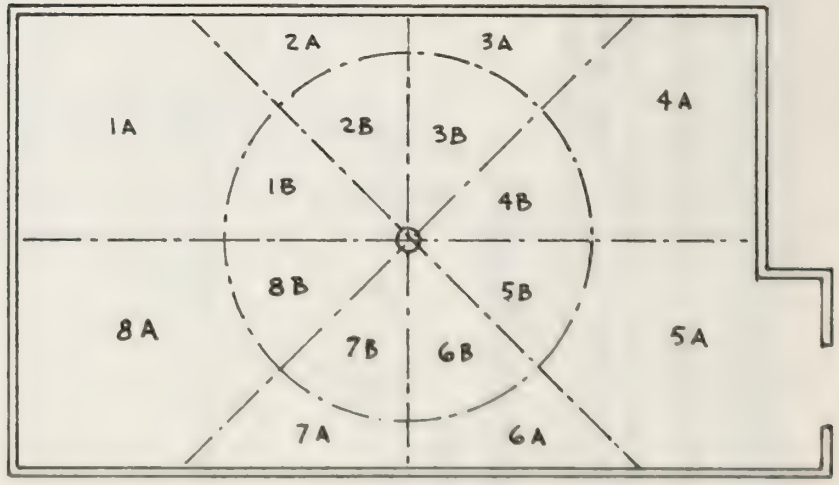
- o Ionization type incipient detector
- o Fixed, multiple lens flame detector
- o Multiple orifice nozzle - fixed or two dimensional motion
- o Computer control

VI-5.2 Operating Sequence:

	Event	
1.	Incipient detector senses fire in room.	o Local alarm sounded. o Cover released and flame detector activated.
2.	Flame detector sees fire.	o Water turned on to nozzle protecting fire zone. o Alarm sent to fire department.
3.	Flame detector sees fire growing.	o Additional nozzles open to protect fire zones and zones ahead of fire.
4.	Flame detector sees fire declining.	o Water to nozzles protecting zones with no fire shut off (time delay.
5.	Flame detector sees no further fire.	o Water off (time delay) o Flame detector continues to look for fire until manually reset.
6.	Flame detector sees fire before the system is manually reset.	o Water turned on to nozzle protecting fire zone.



Example "E" would have 8 double zones as shown below. Examples "C" and "D" could have 16 to 30 or 40 zones, depending on number of "teeth" in ratchet wheel.



8 Double Zones - Ex. "E"

EXAMPLE–E

VI - 5 - A

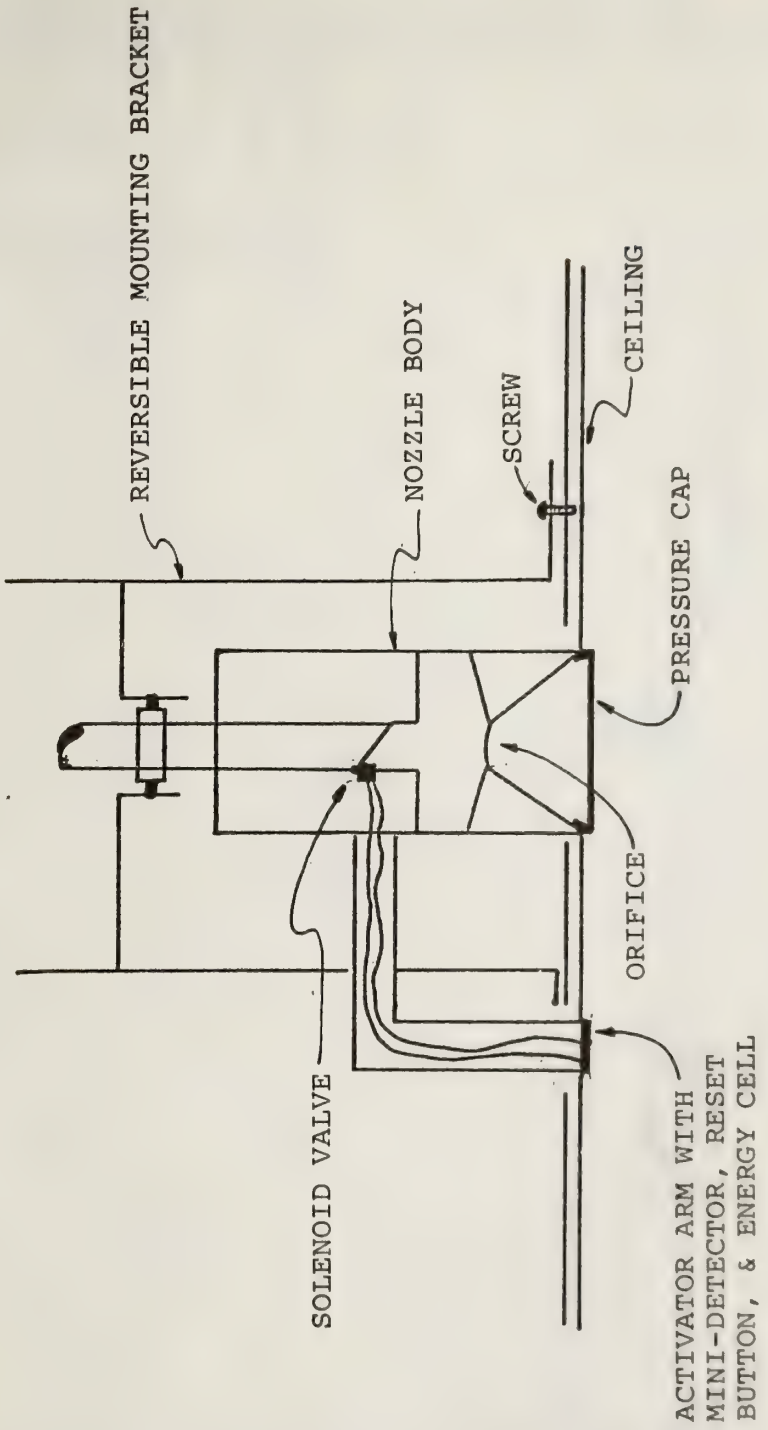
VI-6 Example "F" - Multi-Nozzle System, Closely Spaced, Low Flow Rate, Smoke Sensitive "On-Off" Nozzles

VI-6.1 Example System "F" characteristics:

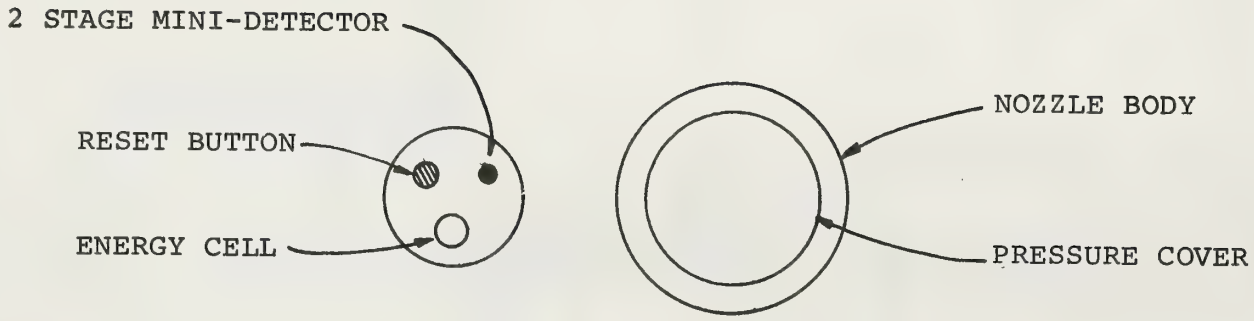
- o 2-stage mini detector, (ionization-type smoke detector and U.V. flame detector)
- o Computer controlled nozzles with variable time delay

VI-6.2 Operating Sequence:

	Event	System Action
1.	Incipient detector senses fire in room.	o Local alarm sounded. o Computer control circuit activated. o All room flame detectors activated.
2.	Flame detector sees fire.	o Water turned on to that nozzle with variable time delay. The time delay between the time the incipient detector senses fire and the water is turned on will be variable as to the time of day so that manual fire fighting action can be taken prior to discharge. o Alarm sent to fire department.
3.	Flame detectors in adjacent zones see fire.	o Adjacent nozzles open immediately in areas where fire is detected and in areas where fire is growing. o Nozzle opening directed by computer control which detects fire growth.
4.	Some flame detectors no longer see fire in adjacent zones	o Nozzles shut off in those zones where fire is no longer detected (time delay).
5.	Flame detectors no longer see fire in any zone	o Water is shut off (time delay). o Flame detectors continue to look for fire until system is manually reset
6.	Flame detectors see fire again prior to system being reset	o Water turned on as directed by computer as it senses fire location.

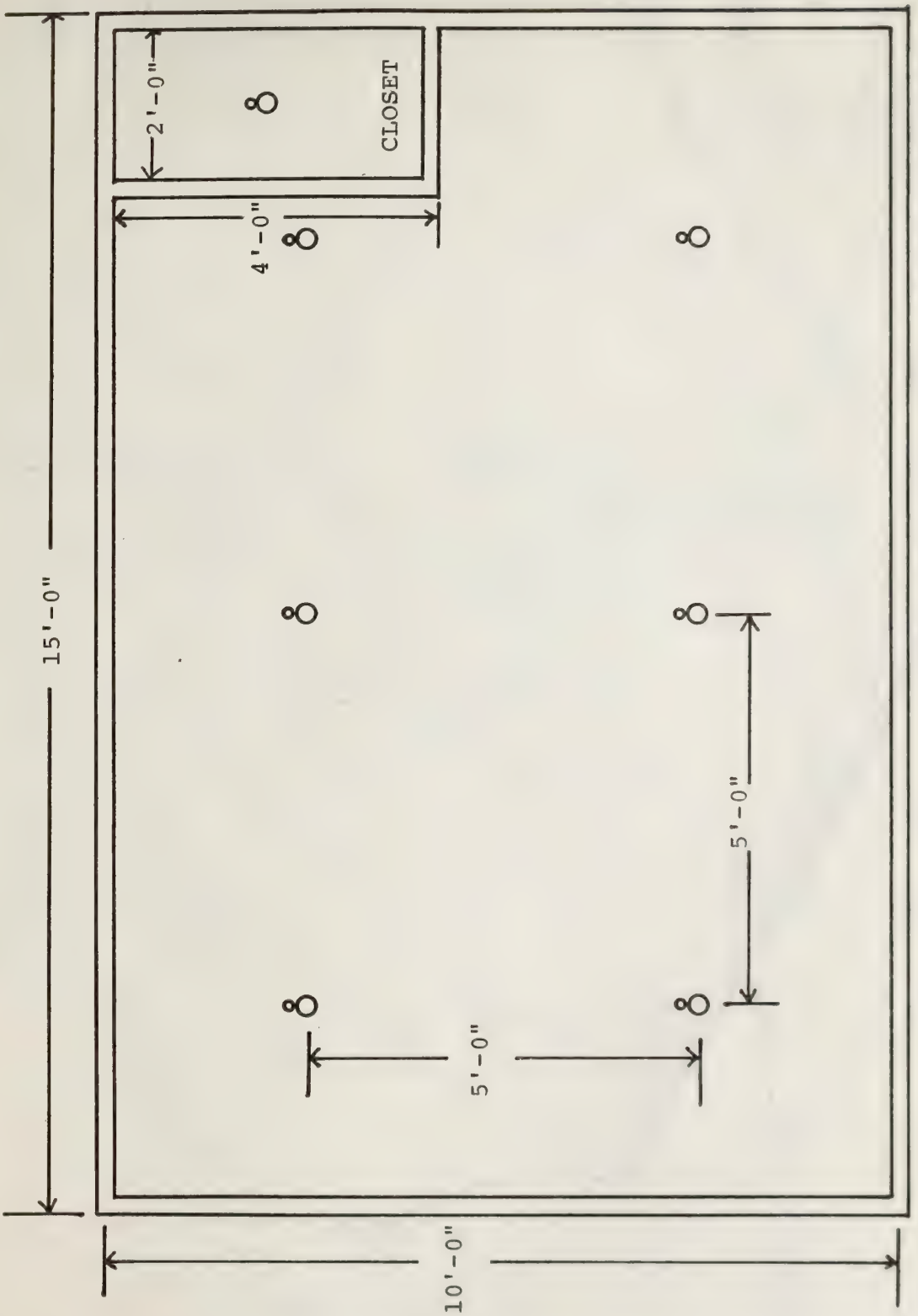

REVERSIBLE MOUNTING BRACKET
NOZZLE BODY
SCREW
CEILING
PRESSURE CAP
ORIFICE
SOLENOID VALVE
ACTIVATOR ARM WITH
MINI-DETECTOR, RESET
BUTTON, & ENERGY CELL

VI-6-A



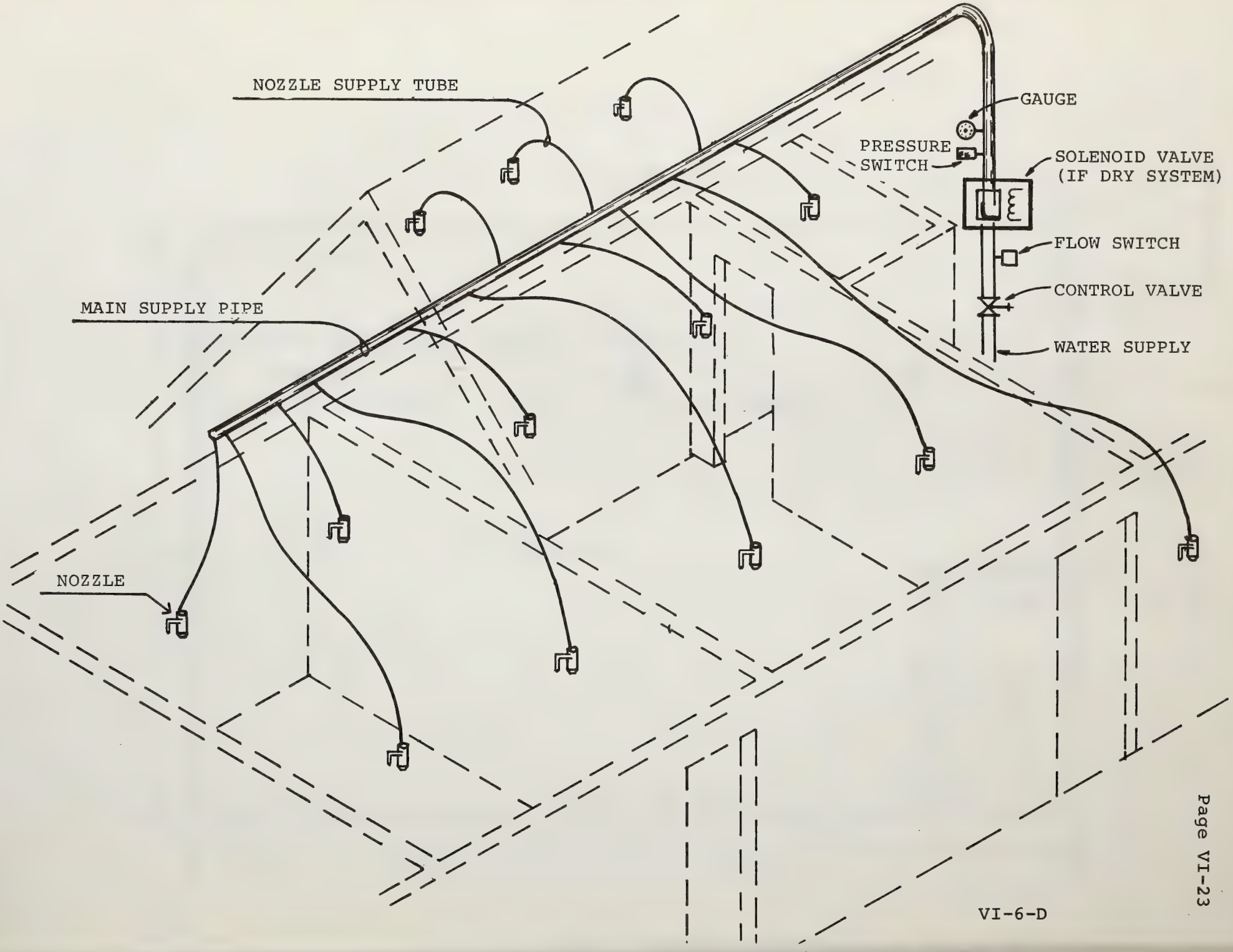
PLAN VIEW

VI-6-B



MASTER BEDROOM

VI-6-C


NOZZLE SUPPLY TUBE
GAUGE
PRESSURE SWITCH
SOLENOID VALVE (IF DRY SYSTEM)
FLOW SWITCH
CONTROL VALVE
MAIN SUPPLY PIPE
WATER SUPPLY
NOZZLE

VI-6-D

APPENDIX VII

REFERENCES

APPENDIX VII

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